Title: Robert Spekkens and Elie Wolfe, Perimeter Institute

Speakers: Robert Spekkens, Elie Wolfe

Collection: Perimeter Public Lectures

Date: October 07, 2020 - 7:00 PM

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Abstract: What do data science and the foundations of quantum theory have to do with one another?

A great deal, it turns out. The particular branch of data science known as causal inference focuses on a problem which is central to disciplines ranging from epidemiology to economics: that of disentangling correlation and causation in statistical data.

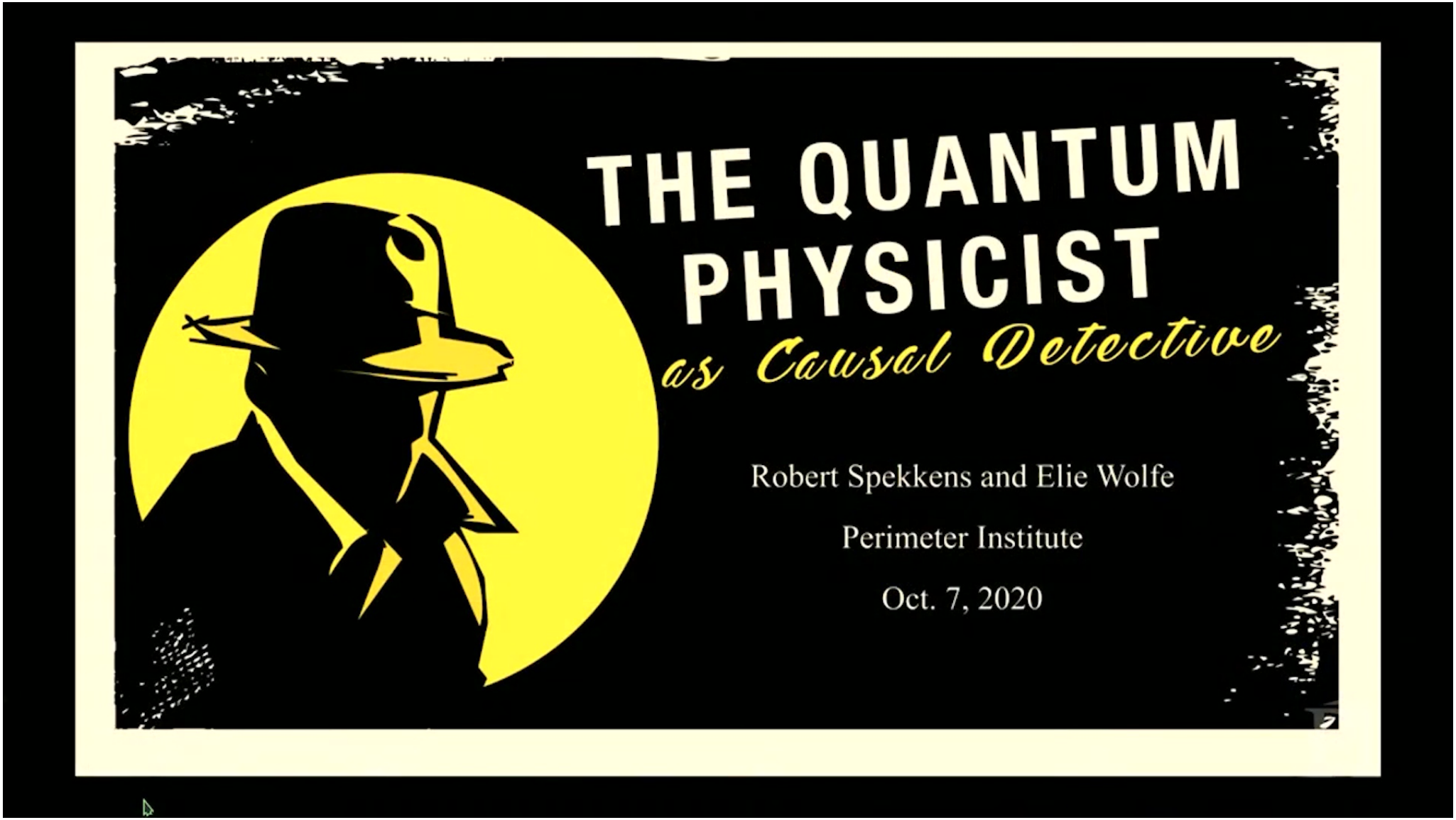
Meanwhile, in a slightly different guise, this same problem has been pondered by quantum physicists as part of a continuing effort to make sense of various puzzling quantum phenomena. On top of that, the most celebrated result concerning quantum theoryâ€™s meaning for the nature of reality â€“ Bellâ€™s theorem â€“ can be seen in retrospect to be built on the solution to a particularly challenging problem in causal inference.

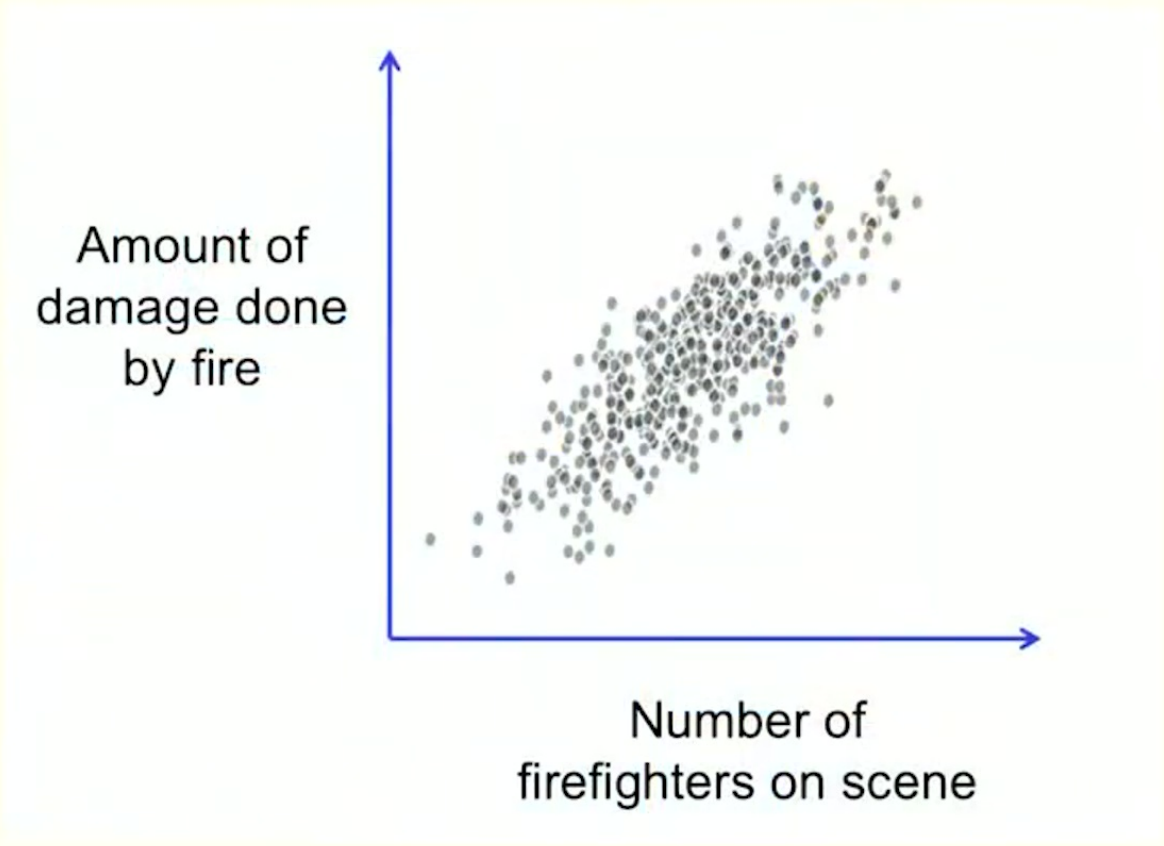
Recent efforts to elaborate upon these connections have led to an exciting flow of techniques and insights across the disciplinary divide.

Perimeter researchers Robert Spekkens and Elie Wolfe have done pioneering work studying relations of cause and effect through a quantum foundational lens, and can be counted among a small number of physicists worldwide with expertise in this field.

In their joint webcast from Perimeter on October 7, Spekkens and Wolfe will explore what is happening at the intersection of these two fields and how thinking like a quantum physicist leads to new ways of sussing out cause and effect from correlation patterns in statistical data.

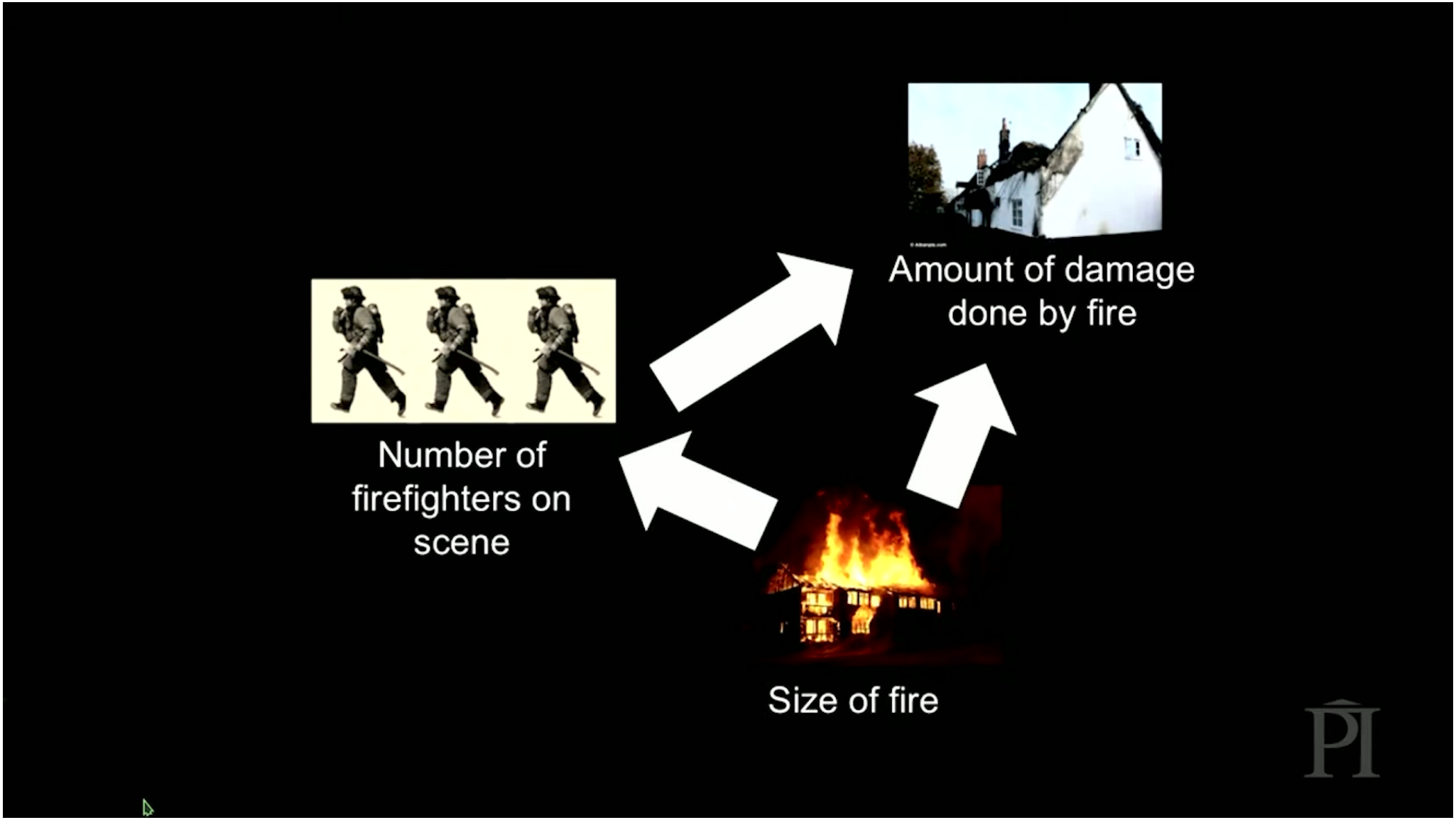
Watch live online at insidetheperimeter.ca.

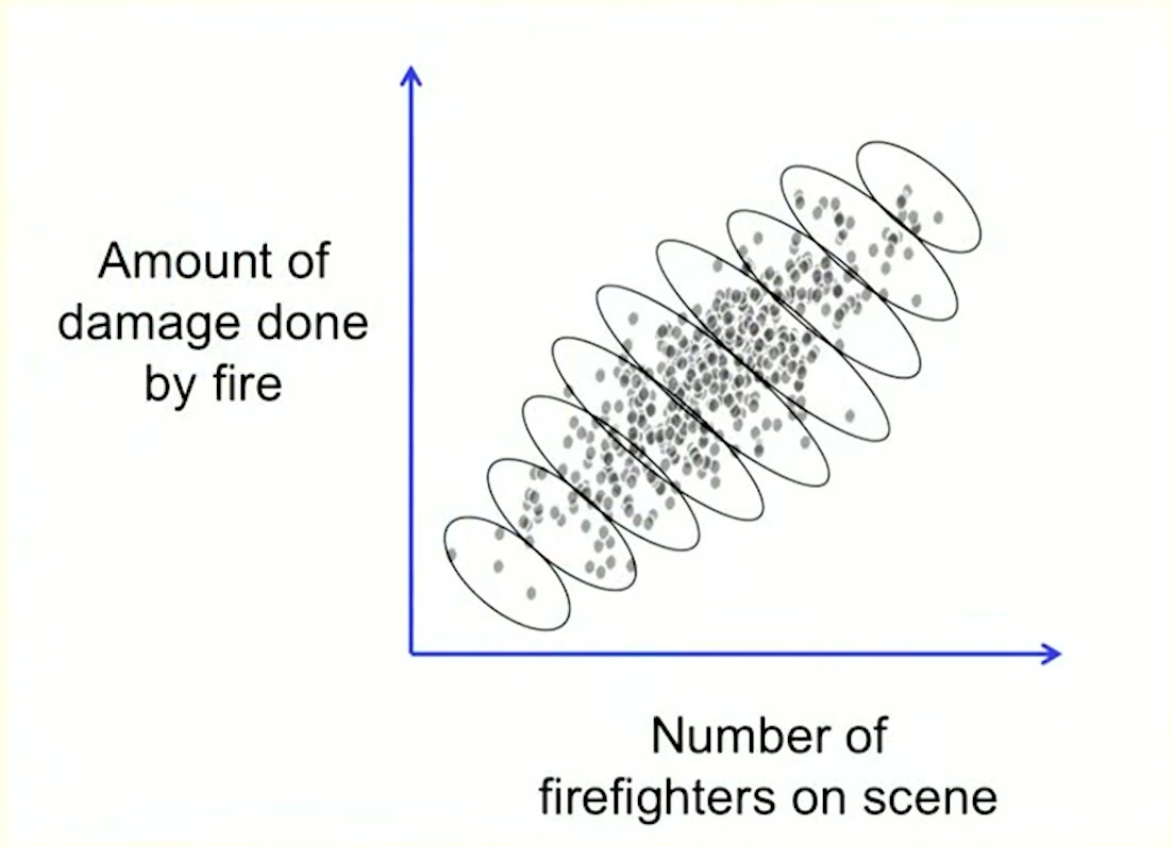

THE QUANTUM PHYSICIST
as Causal Detective
Robert Spekkens and Elie Wolfe
Perimeter Institute
Oct. 7, 2020

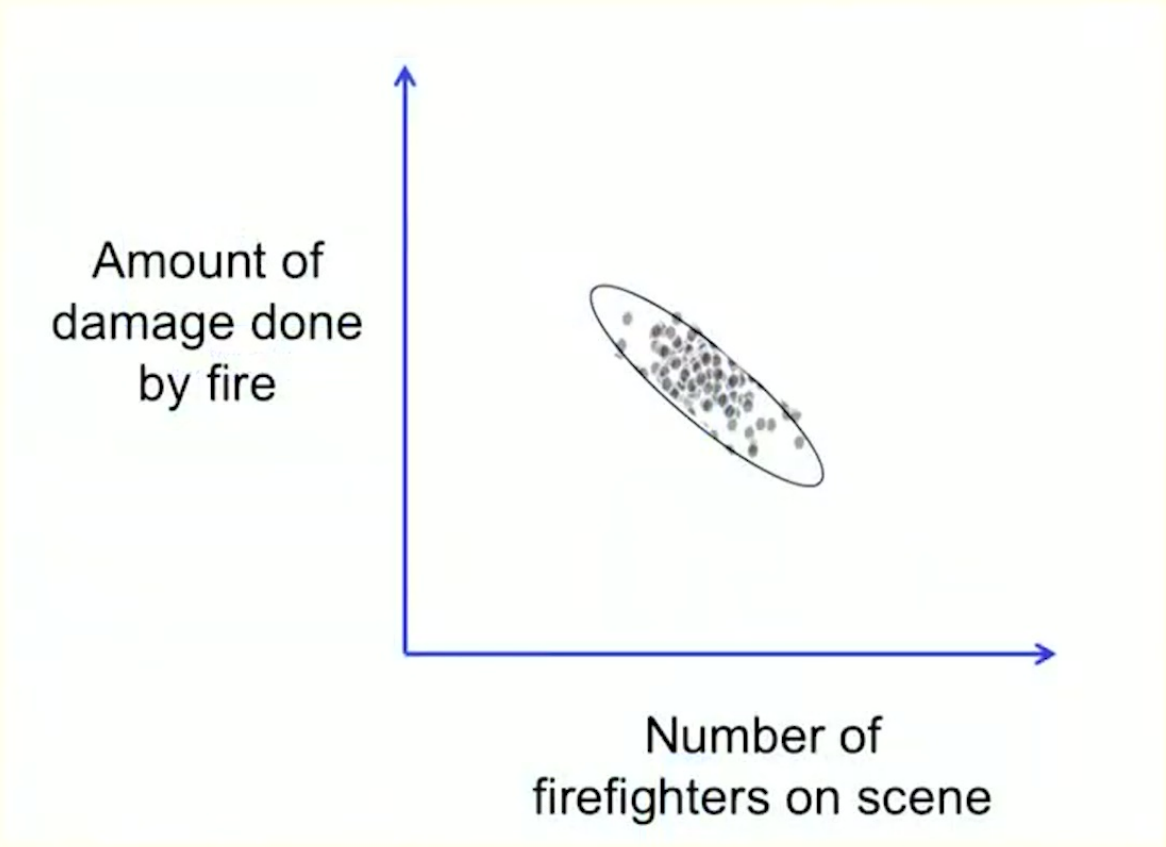

Amount of damage done by fire
Number of firefighters on scene

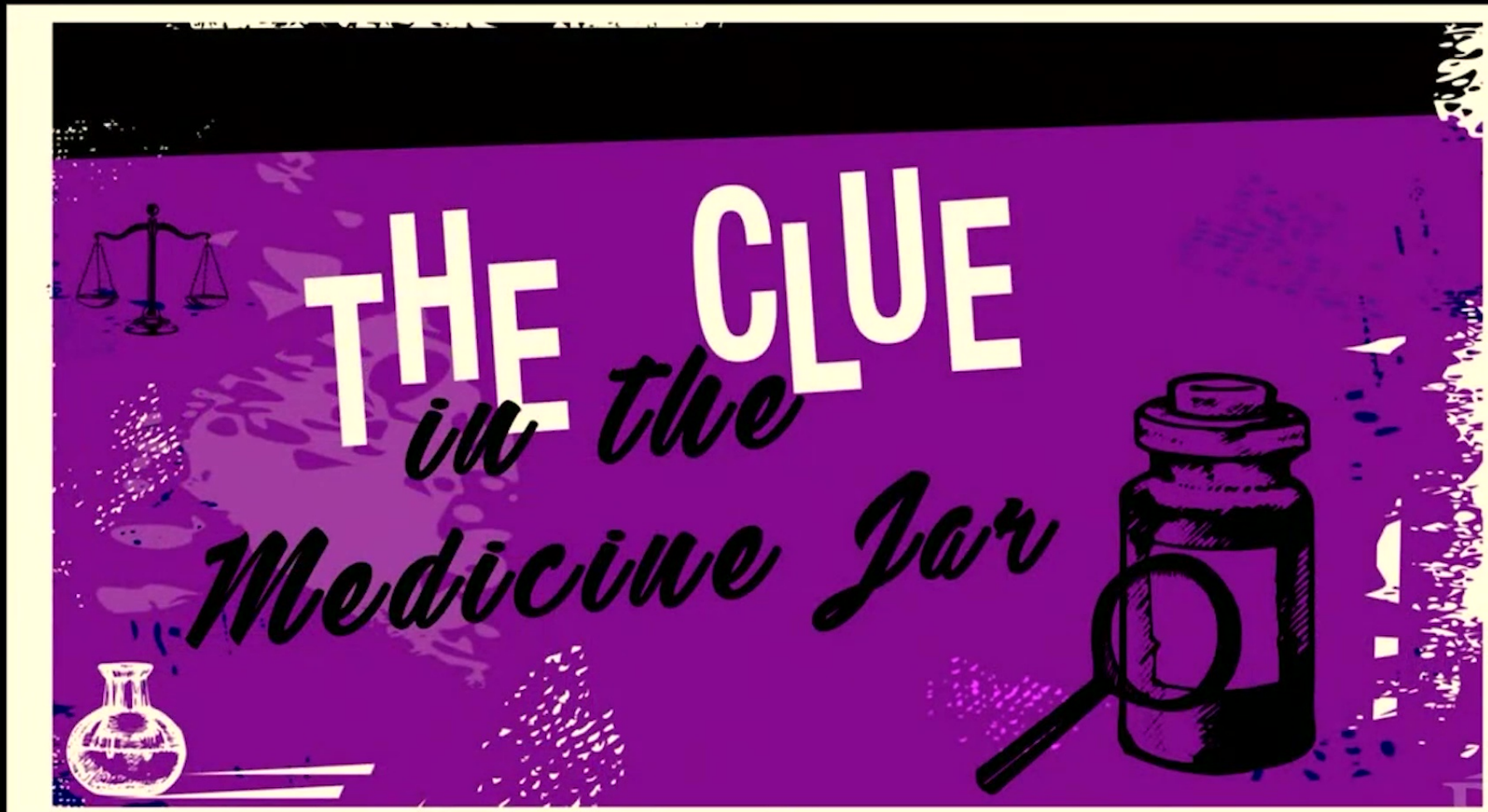
Number of firefighters on scene

Amount of damage done by fire


Amount of damage done by fire
Number of firefighters on scene
Size of fire

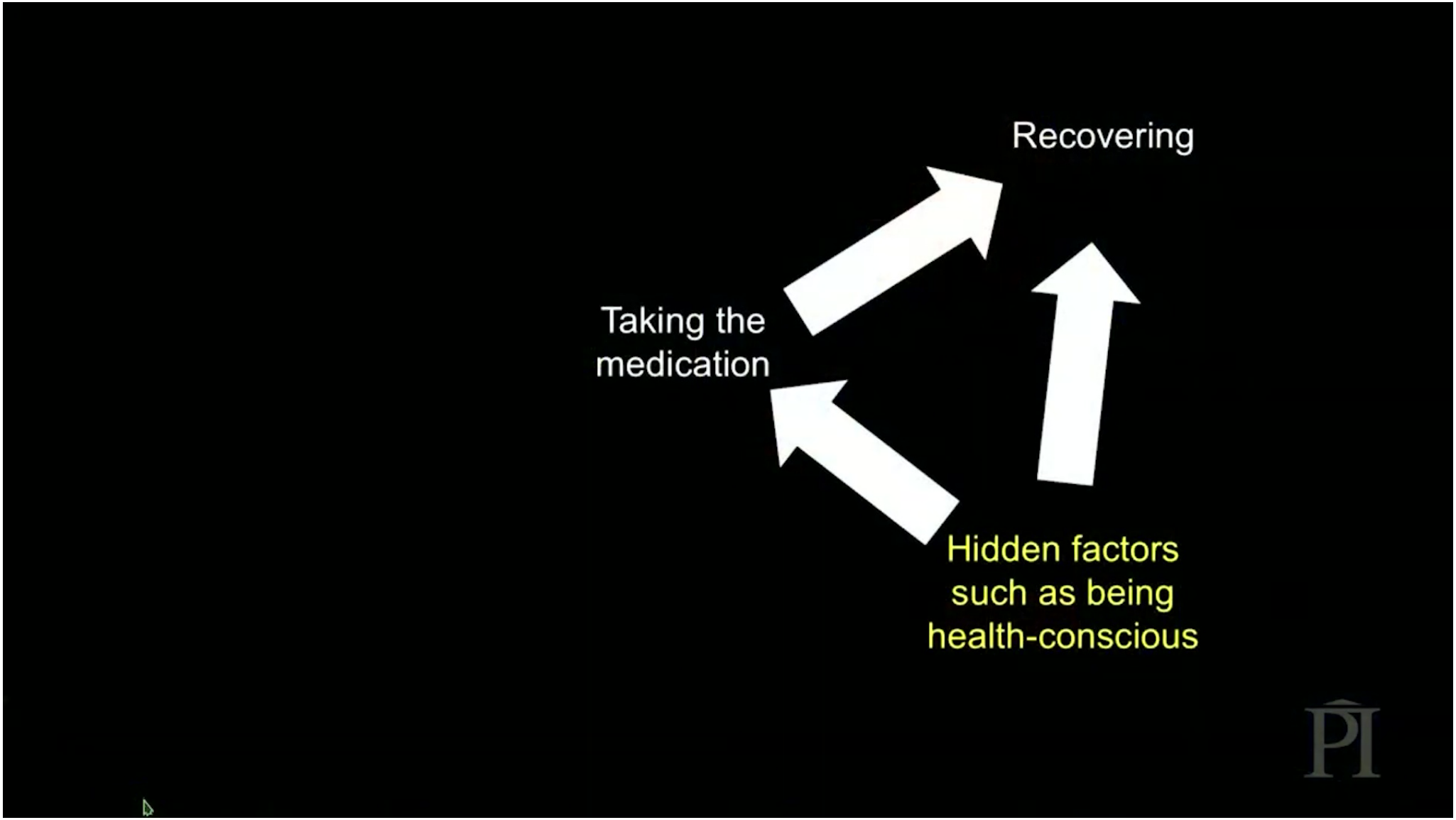

Amount of damage done by fire
Number of firefighters on scene

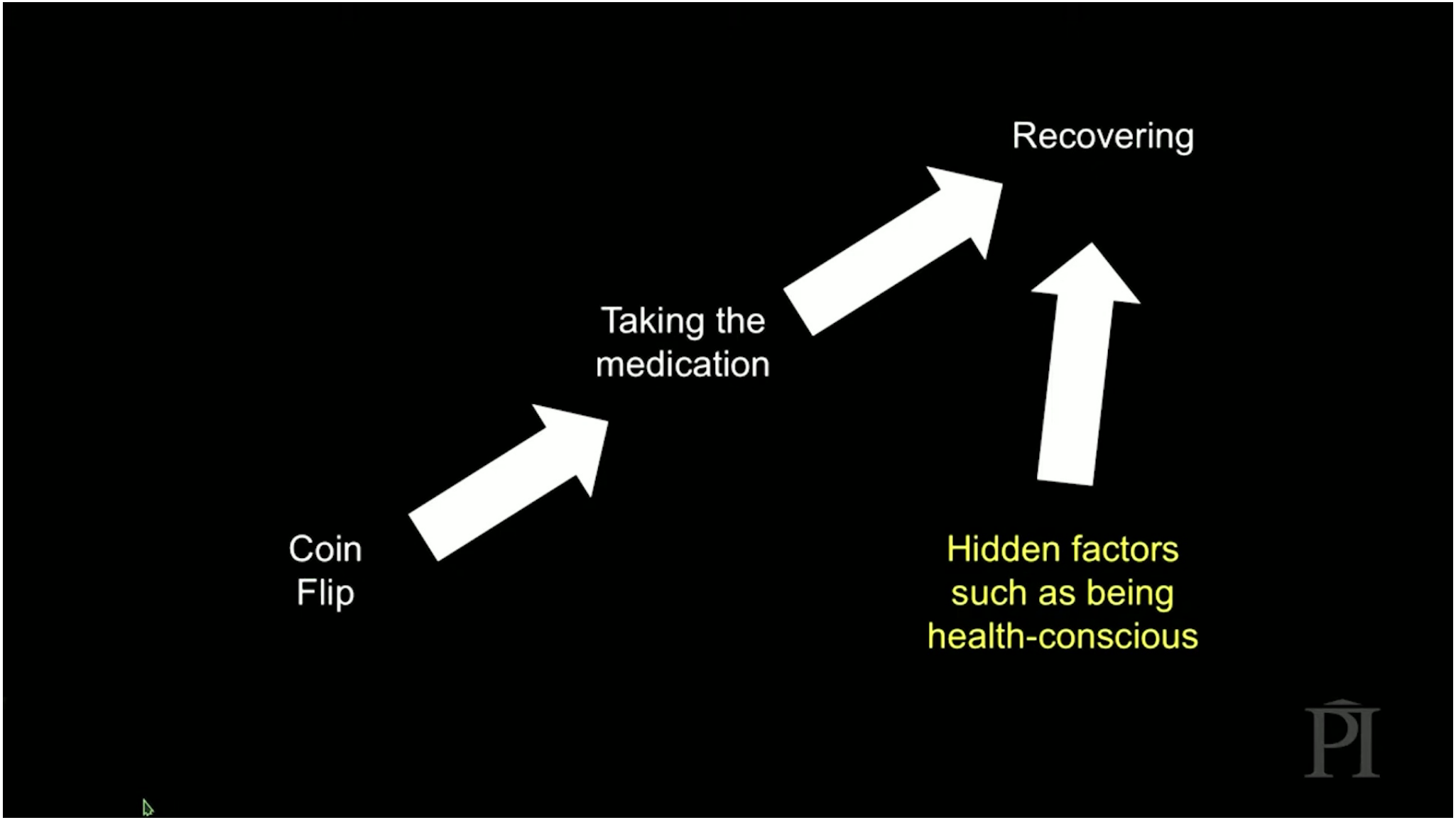

Amount of damage done by fire
Number of firefighters on scene

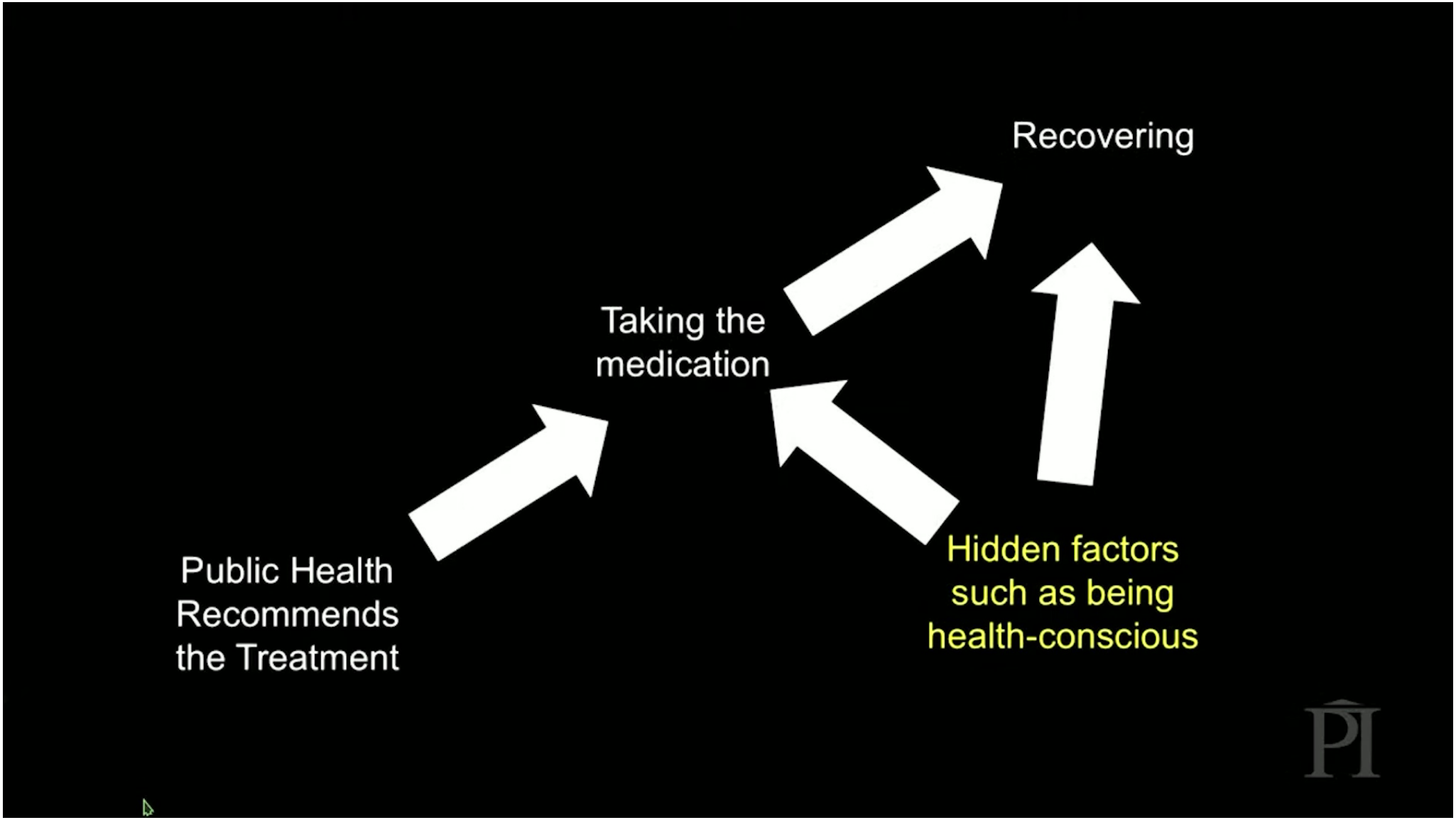

THE CLUE
in the
Medicine Jar

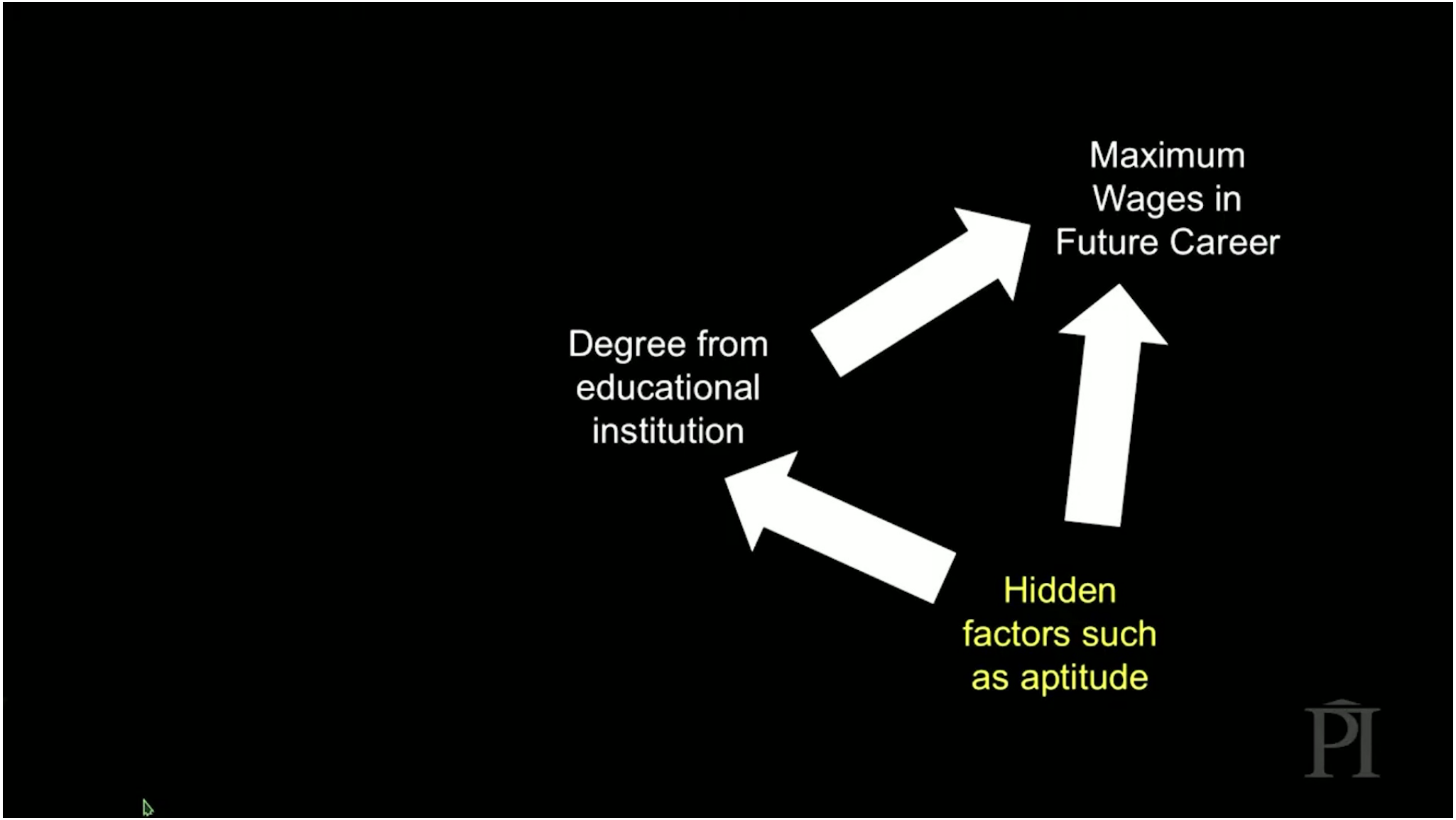
Recovering

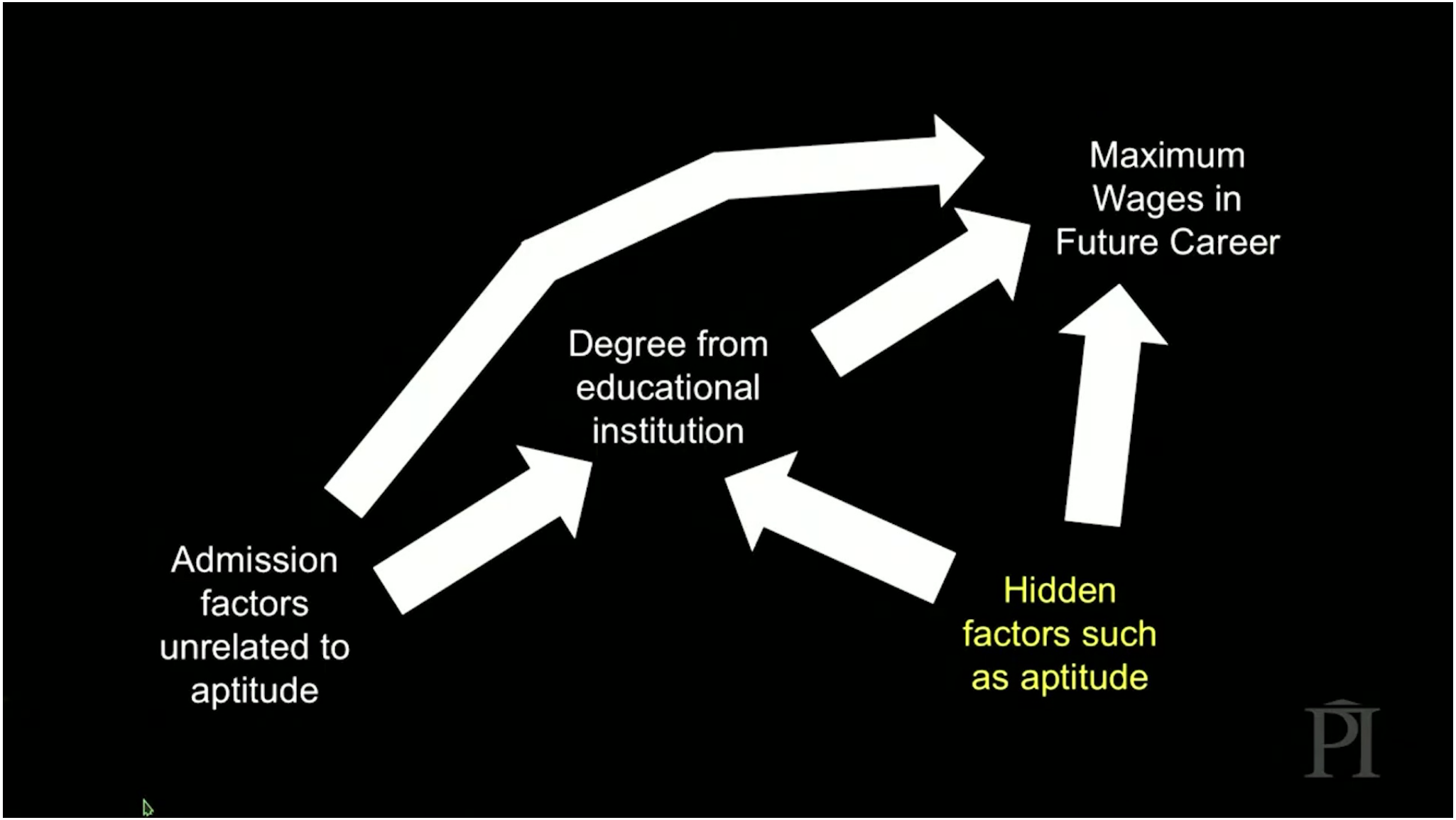
Taking the medication	Yes	No
Yes	79%	21%
No	43%	57%


Recovering
Taking the medication
Hidden factors such as being health-conscious


Recovering
Taking the medication
Coin Flip
Hidden factors such as being health-conscious

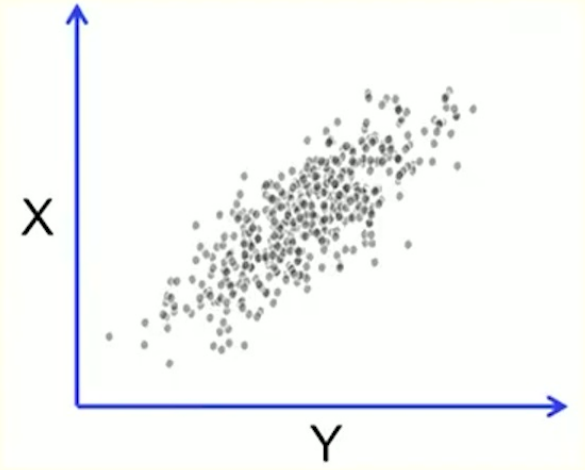

Recovering
Taking the medication
Public Health Recommends the Treatment
Hidden factors such as being health-conscious


Maximum
Wages in
Future Career
Degree from
educational
institution
Hidden
factors such
as aptitude

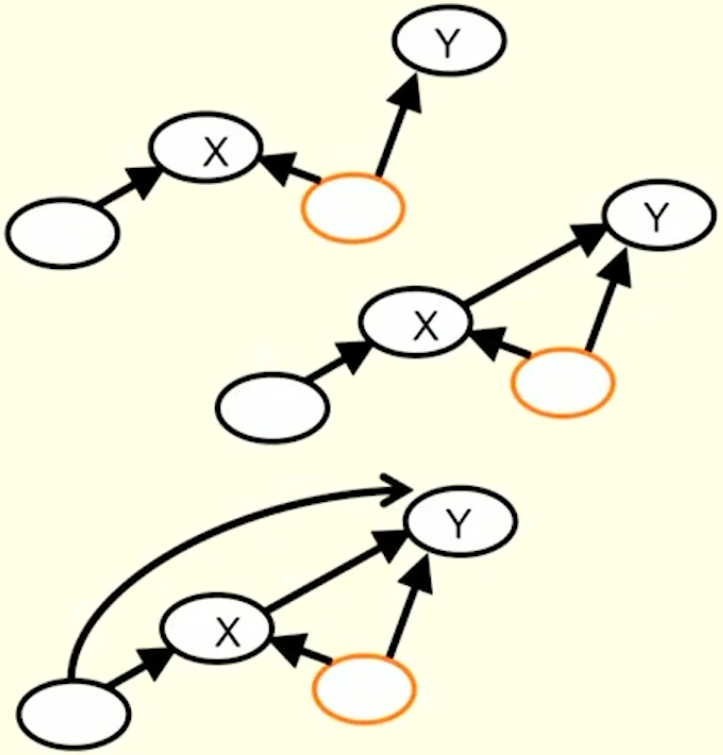

Maximum
Wages in
Future Career
Degree from
educational
institution
Admission
factors
unrelated to
aptitude
Hidden
factors such
as aptitude

The evidence

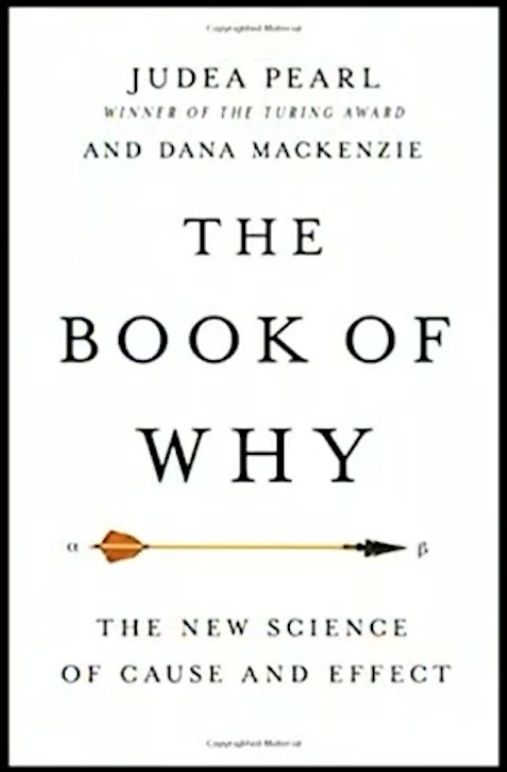
	Y=0	Y=1
X=0	0.797	0.203
X=1	0.390	0.610



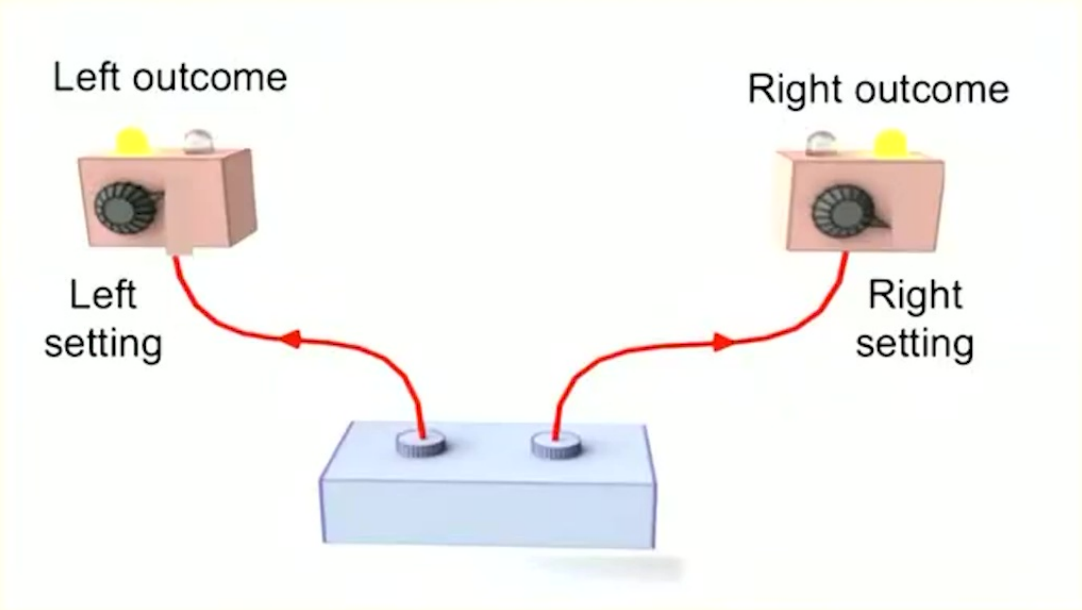
The suspects



Judea Pearl


JUDEA PEARL
WINNER OF THE TURING AWARD
AND DANA MACKENZIE
THE
BOOK OF
WHY
α
β
THE NEW SCIENCE
OF CAUSE AND EFFECT

John Stuart Bell


Left outcome
Right outcome
Left
setting
Right
setting

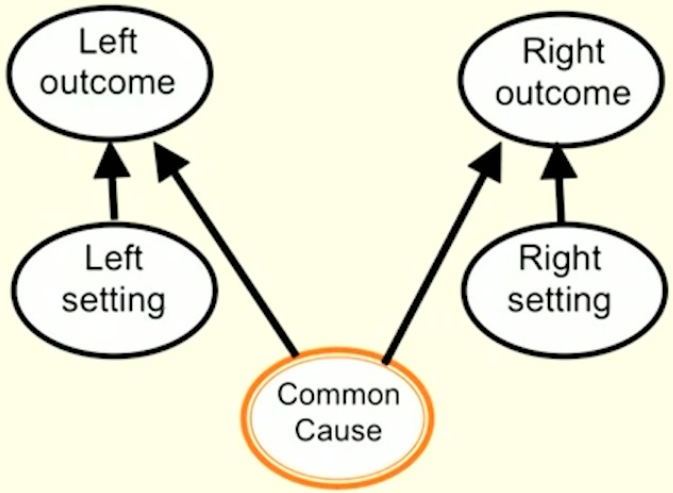
Left setting and Right setting	Left outcome and Right outcome: 0 and 0	0 and 1	1 and 0	1 and 1
0 and 0	43%	7%	7%	43%
0 and 1	43%	7%	7%	43%
1 and 0	43%	7%	7%	43%
1 and 1	7%	43%	43%	7%

The evidence

Left outcome and Right outcome

Left setting and Right setting	0 and 0	0 and 1	1 and 0	1 and 1
0 and 0	43%	7%	7%	43%
0 and 1	43%	7%	7%	43%
1 and 0	43%	7%	7%	43%
1 and 1	7%	43%	43%	7%

The 1st suspect

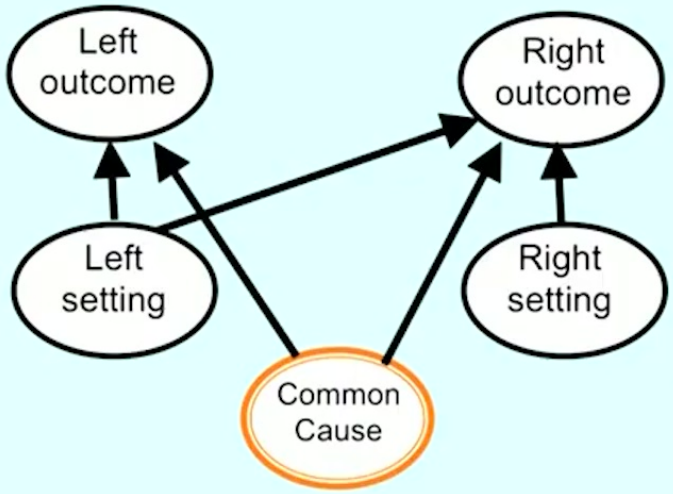


The evidence

The 2nd suspect

Left outcome and Right outcome

Left setting and Right setting	0 and 0	0 and 1	1 and 0	1 and 1
0 and 0	43%	7%	7%	43%
0 and 1	43%	7%	7%	43%
1 and 0	43%	7%	7%	43%
1 and 1	7%	43%	43%	7%



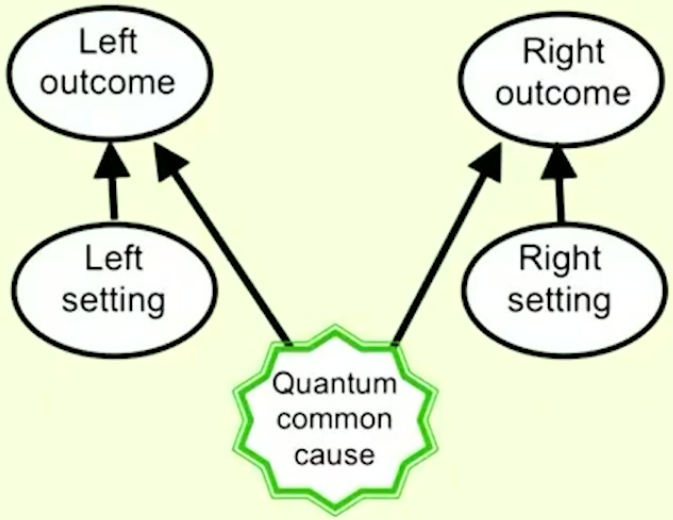
Compatible

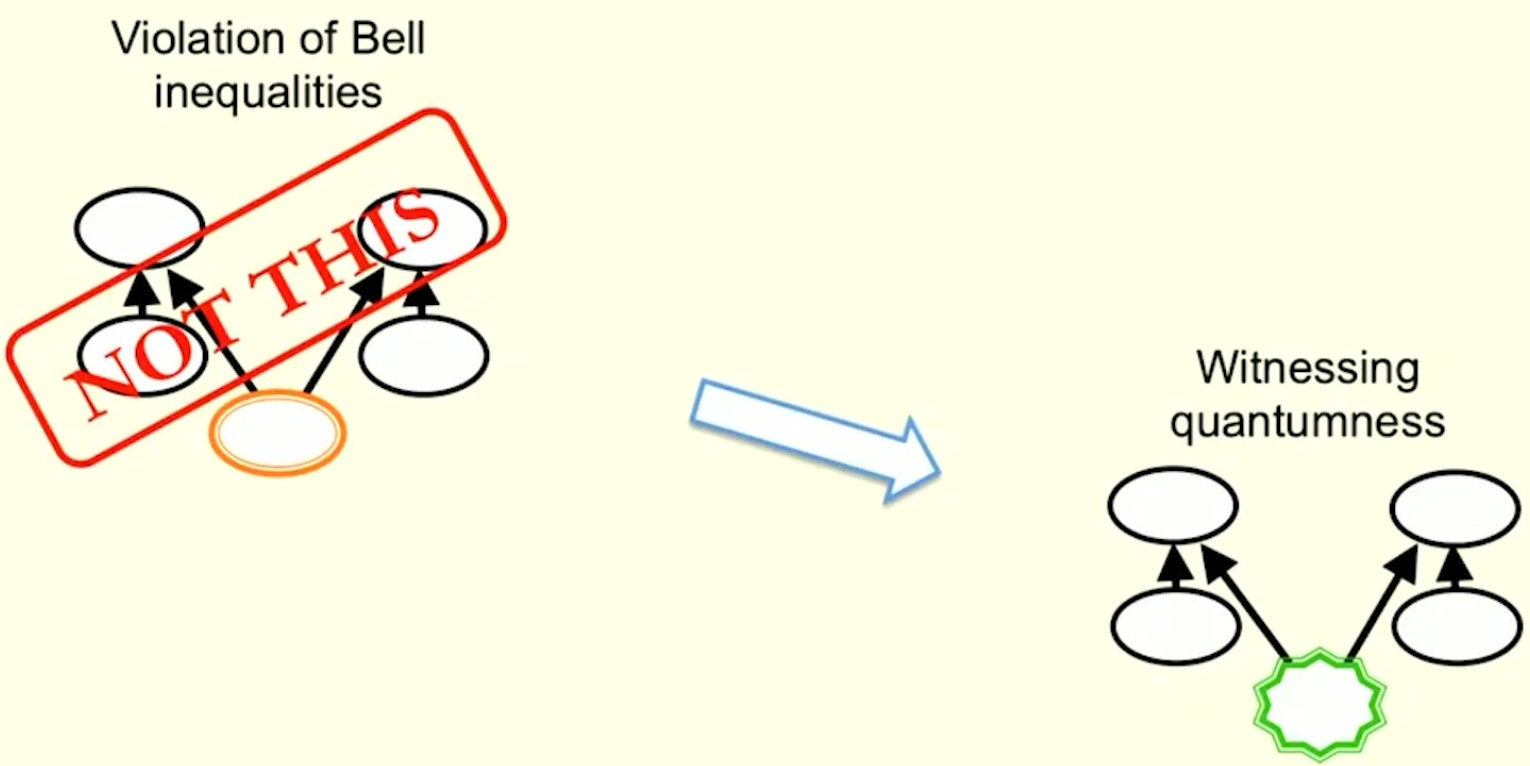
The evidence

Left outcome and Right outcome

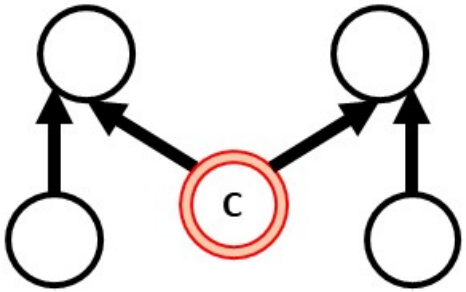
Left setting and Right setting	0 and 0	0 and 1	1 and 0	1 and 1
0 and 0	43%	7%	7%	43%
0 and 1	43%	7%	7%	43%
1 and 0	43%	7%	7%	43%
1 and 1	7%	43%	43%	7%

The 3rd suspect

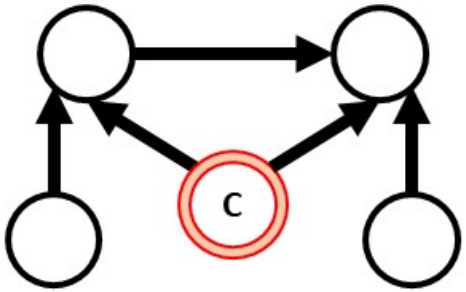



Violation of Bell inequalities
NOT THIS
Witnessing quantumness

“Eliminate the Impossible”

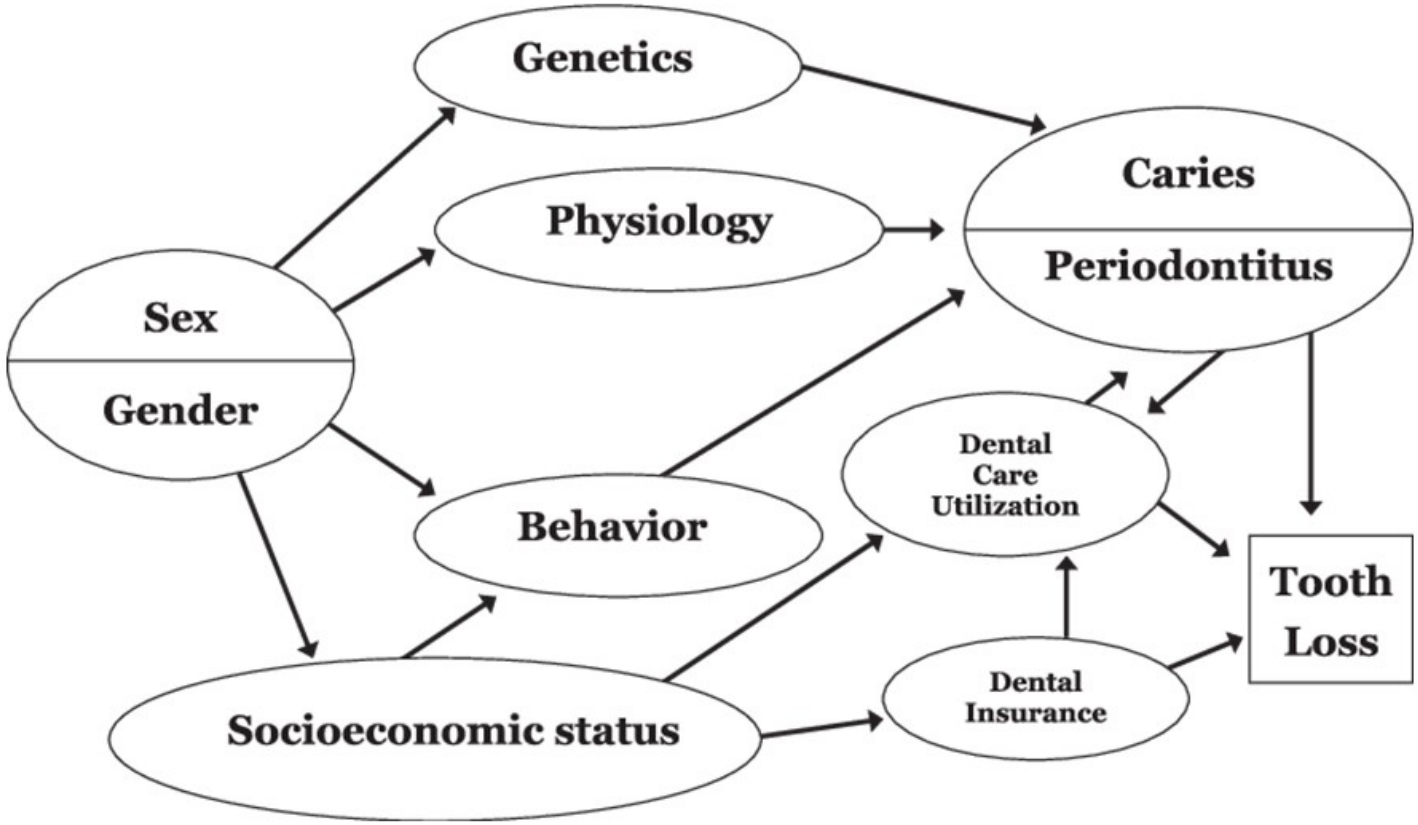


vs.



Causa 1964!

Causal Structures come in Great Variety



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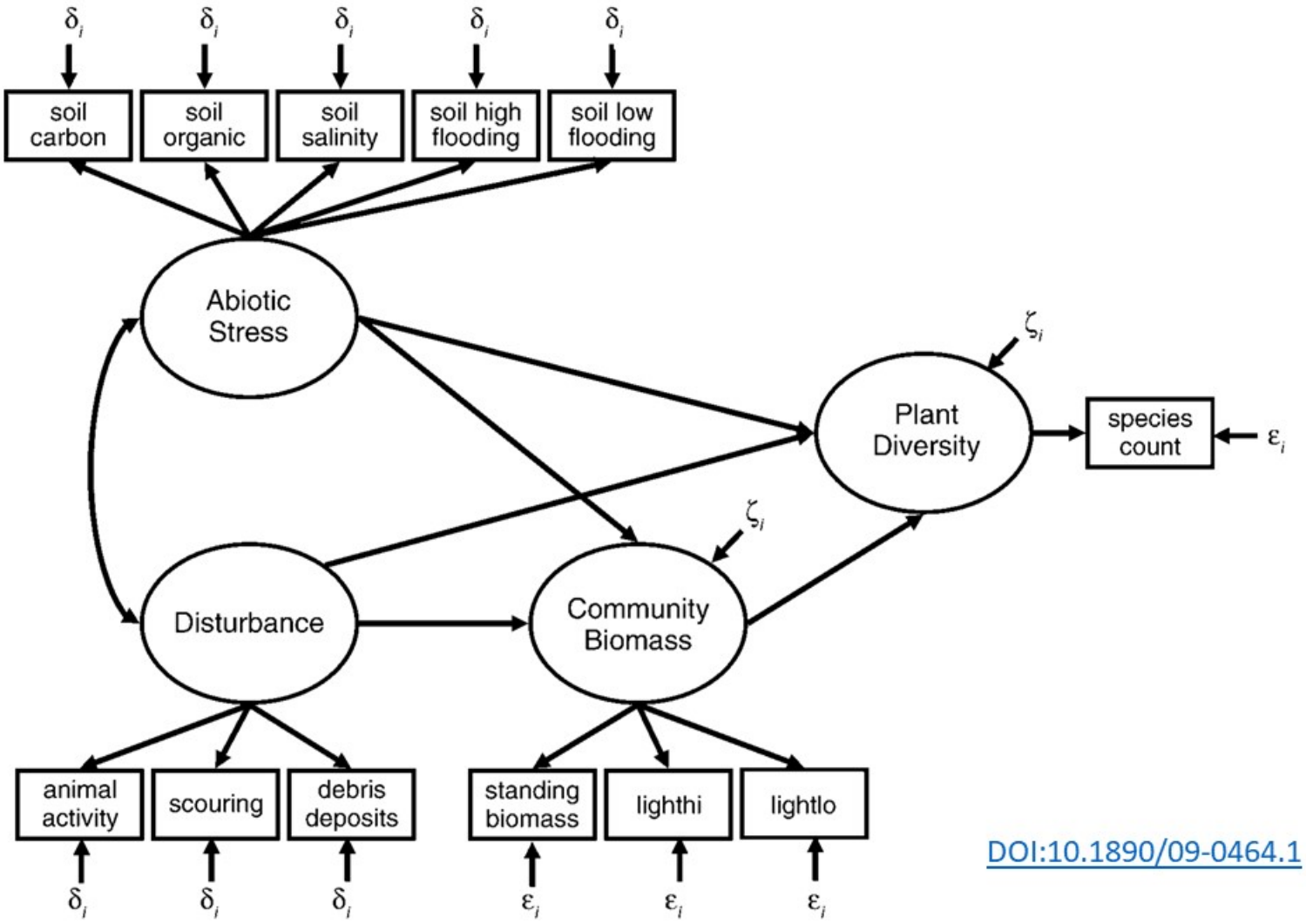

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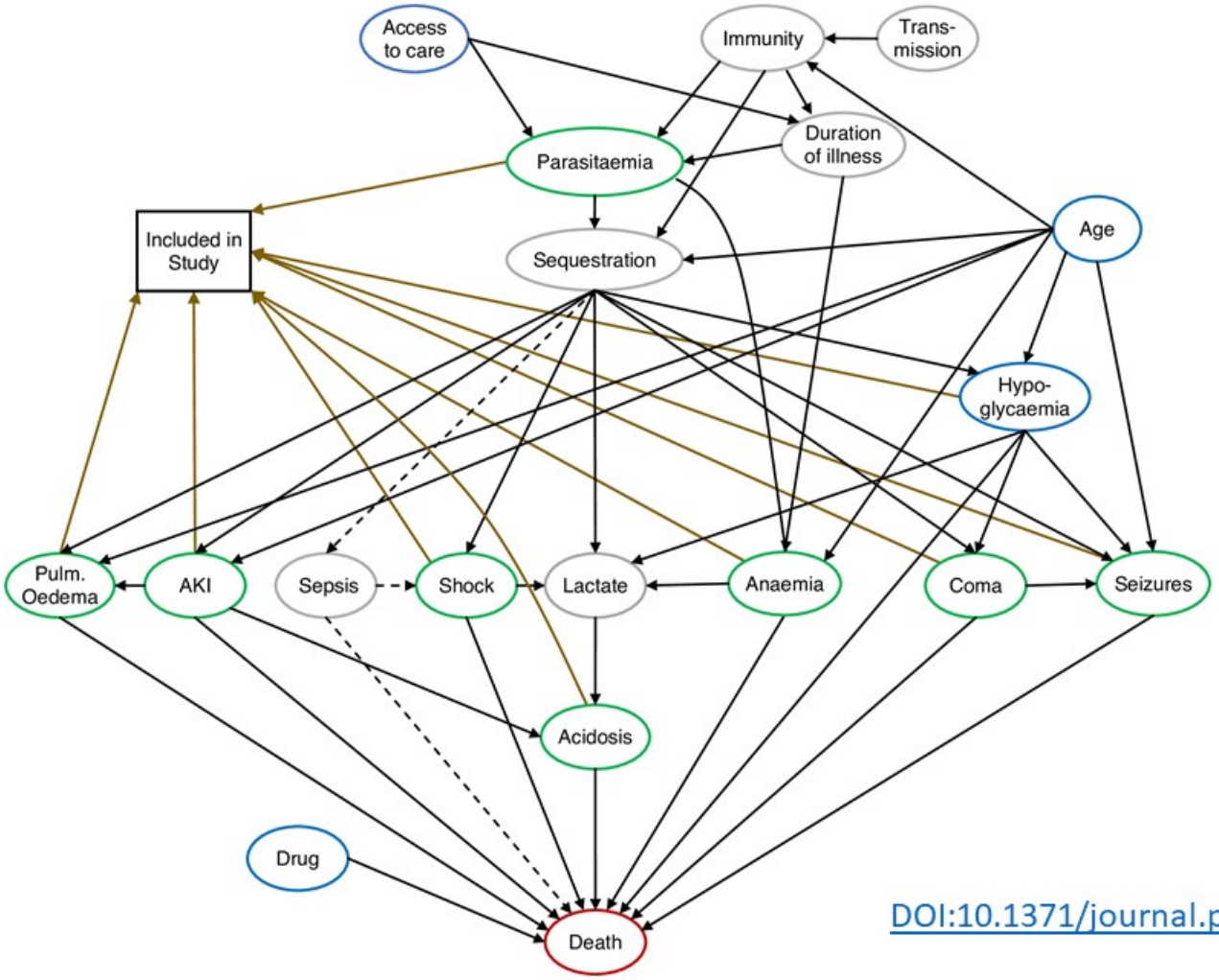
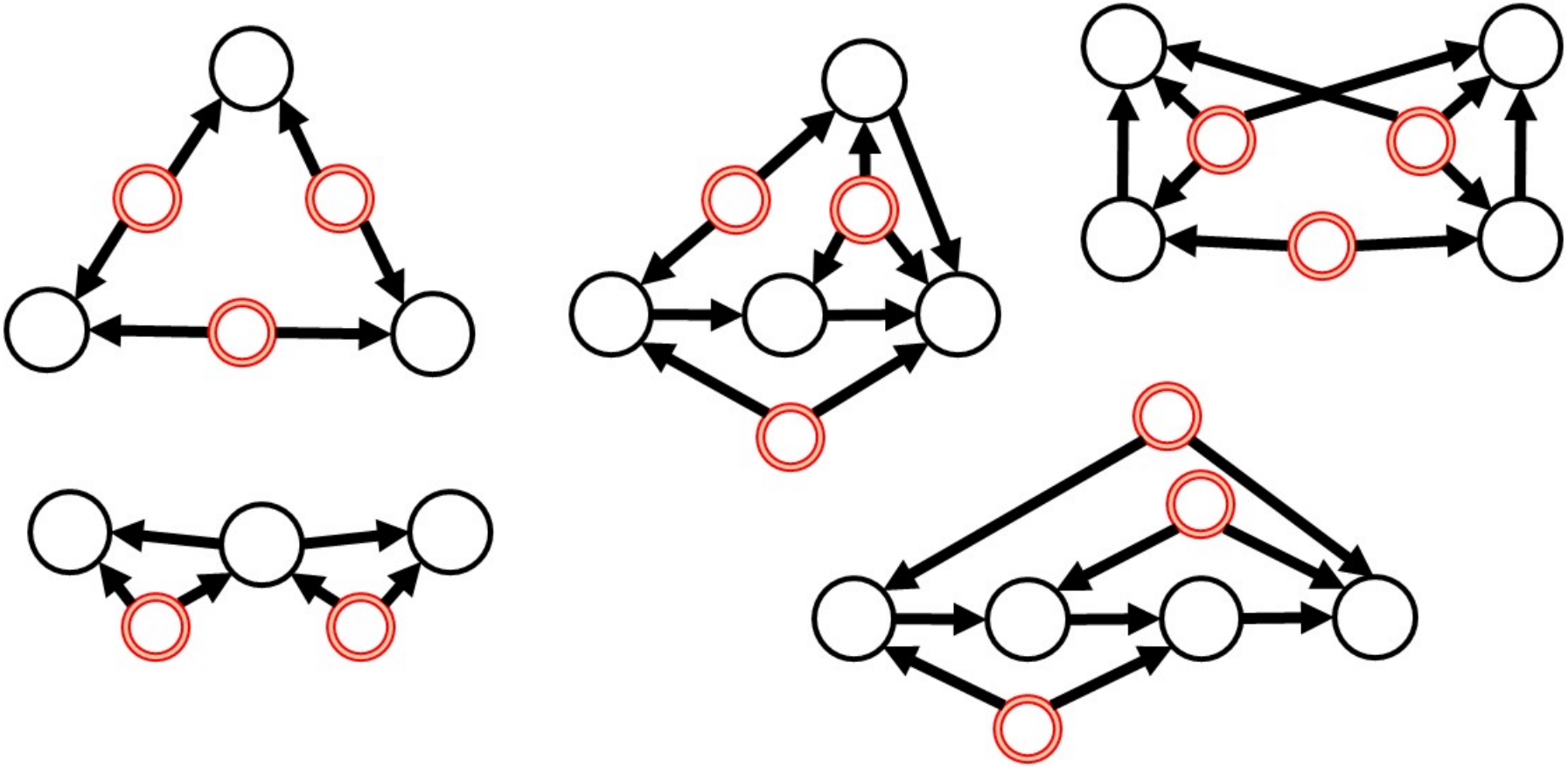
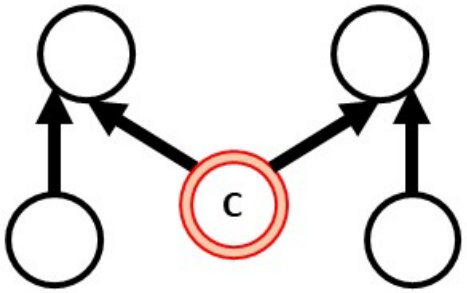


DOI:10.1371/journal.pmed.1002858

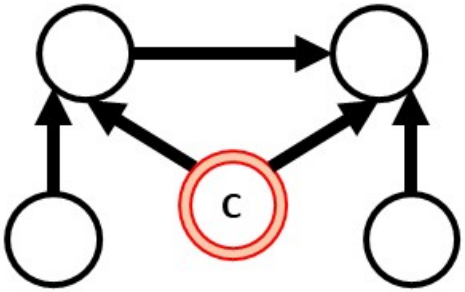
50 years of experience

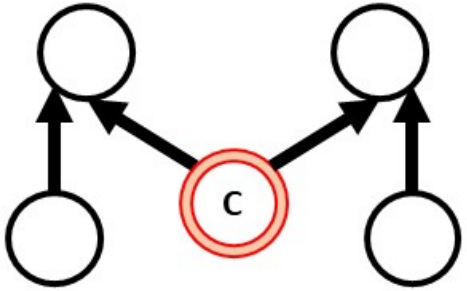
“The Inflation Technique for Causal Inference”



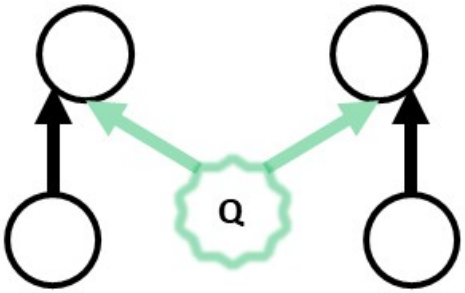


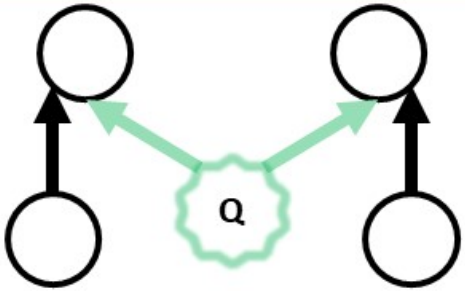
Classical vs. Classical



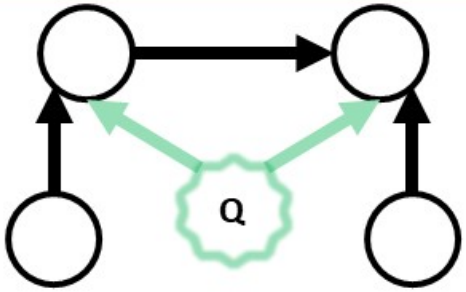


Classical vs. Quantum

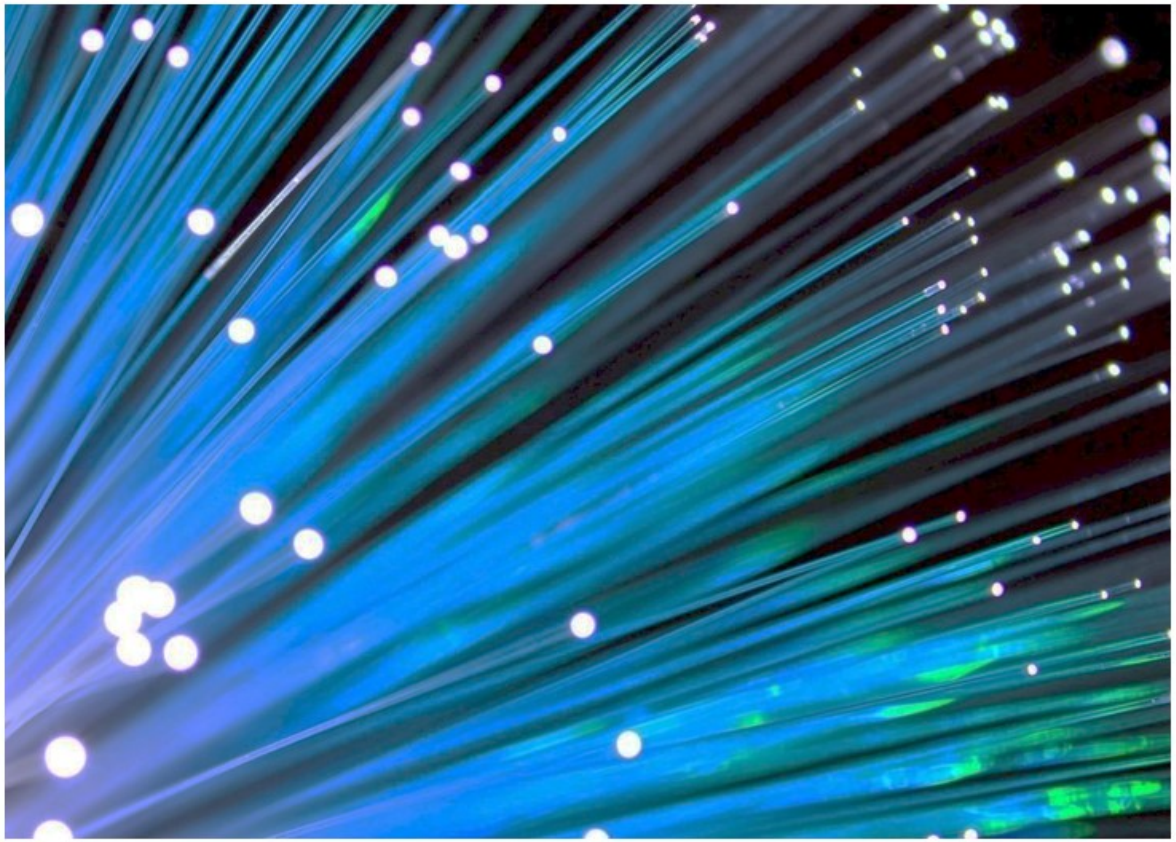


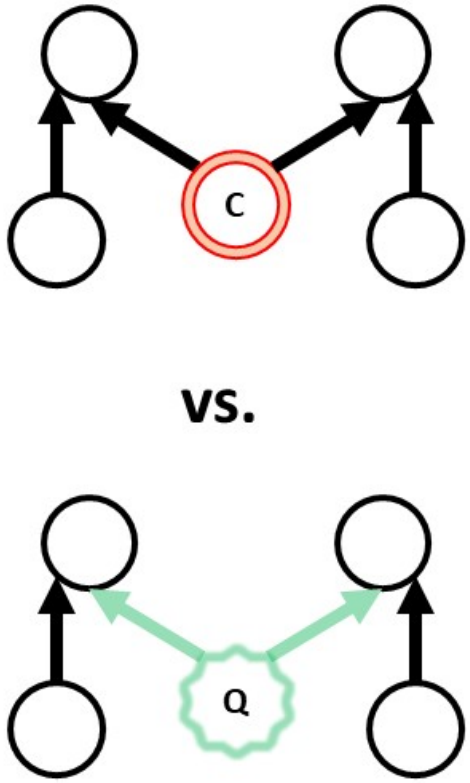


Quantum vs. Quantum

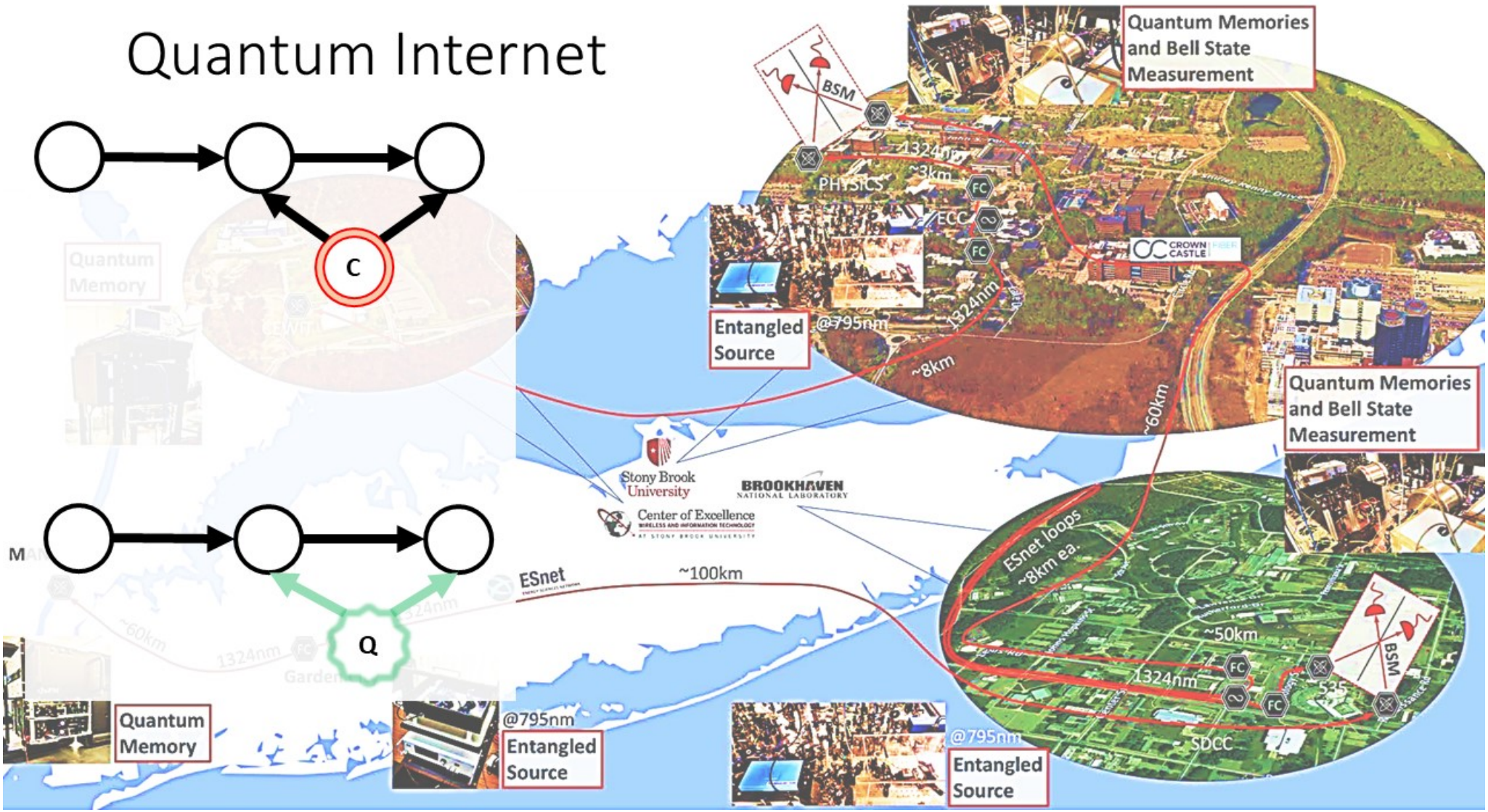


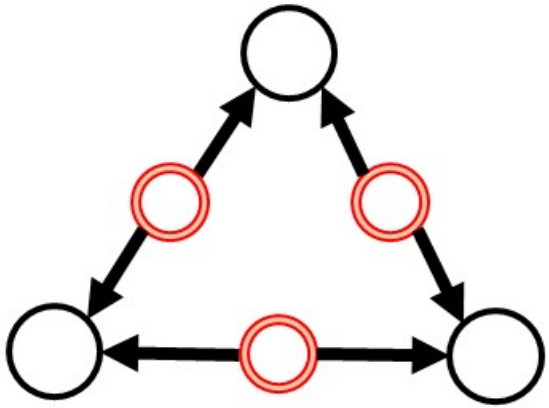
Quantum Cryptography





Quantum Internet





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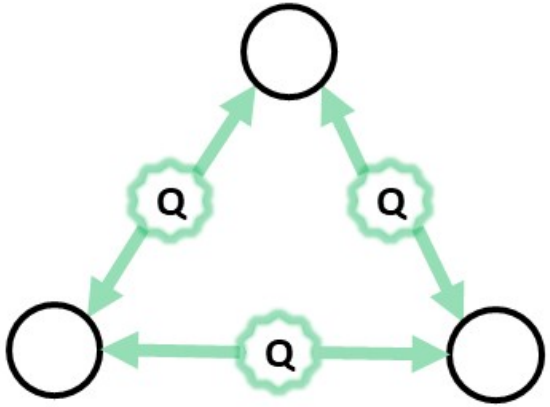
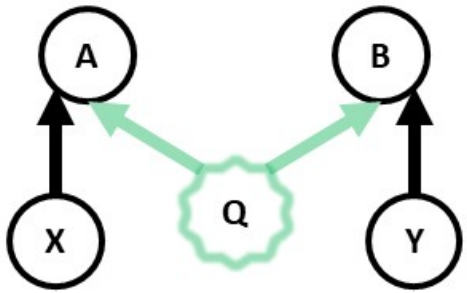


Quantum vs. Quantum



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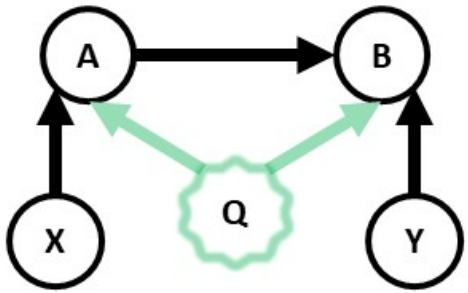
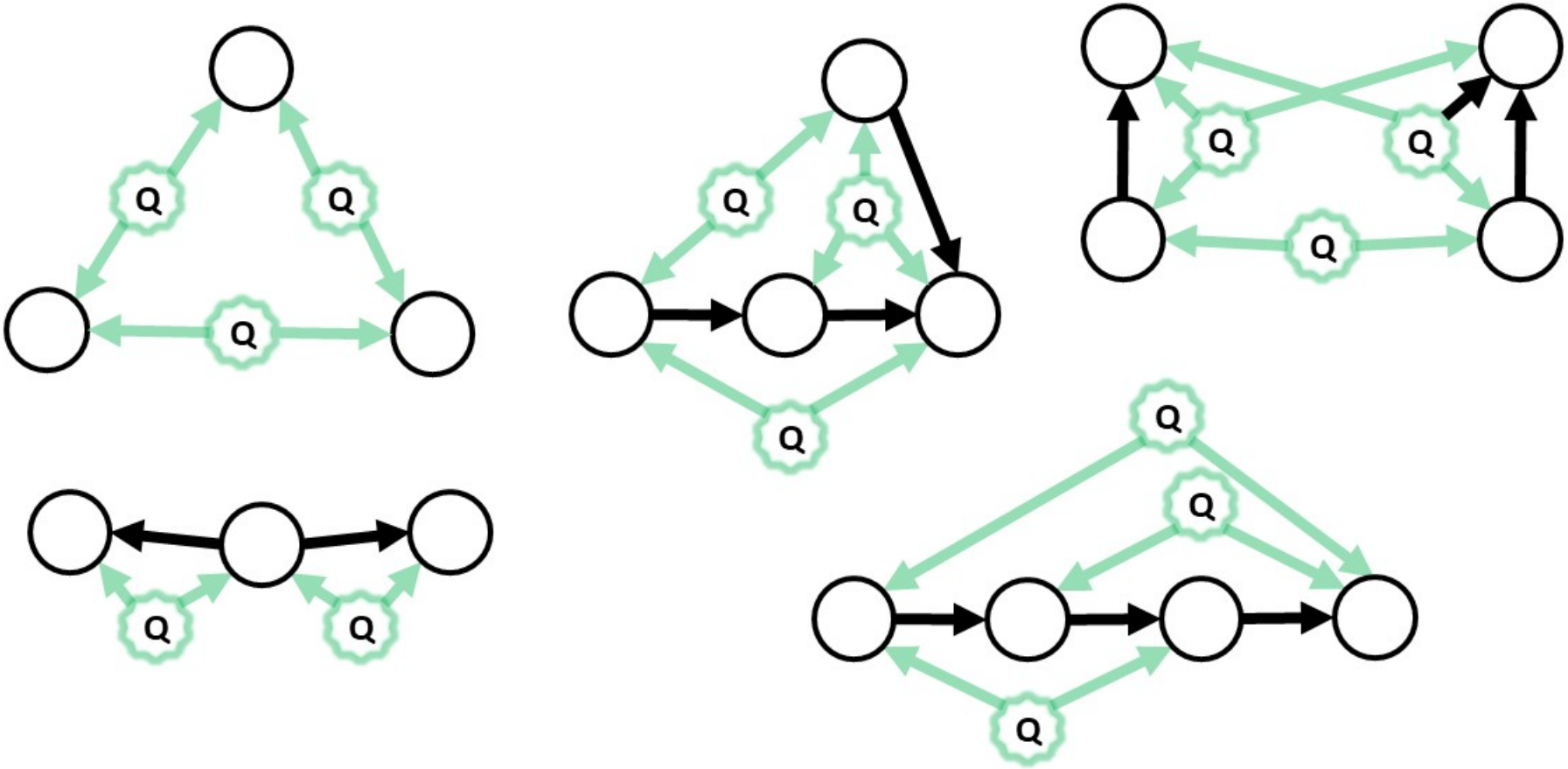


Causal inference in the presence of **quantum** **common causes**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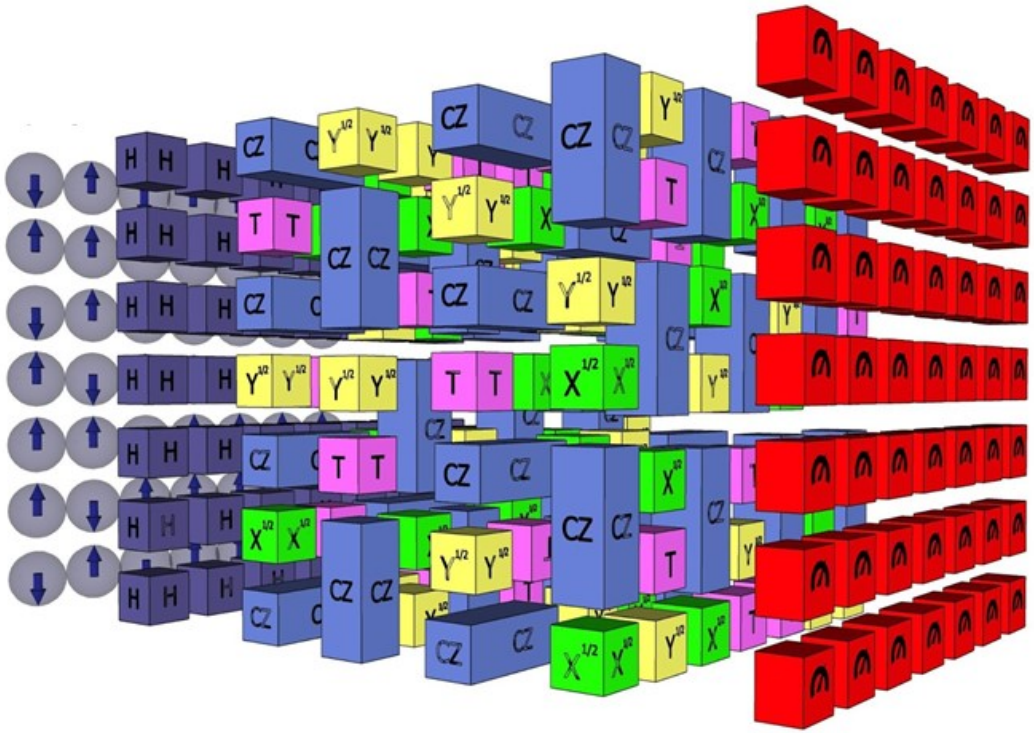
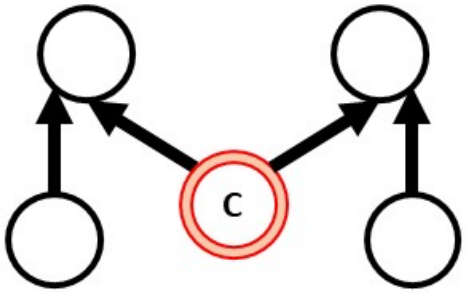
Hardware Diagnostics

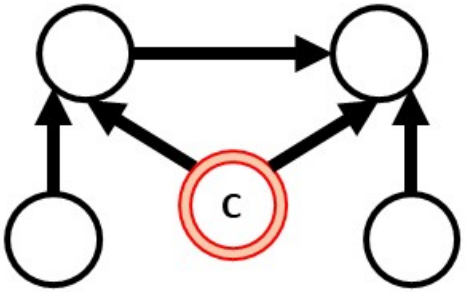


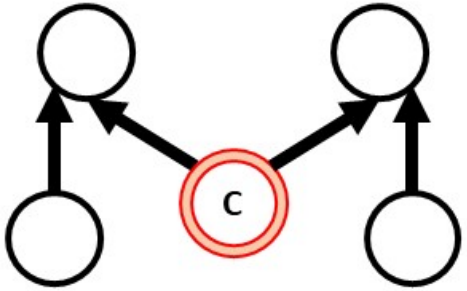
ai.googleblog.com/2018/05/the-question-of-quantum-supremacy.html



Classical vs. Classical

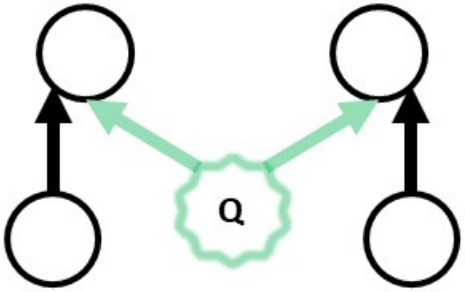
Physicists have experience

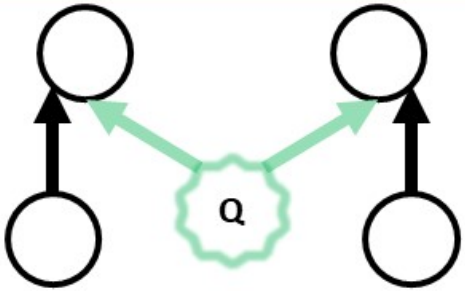




Classical vs. Quantum

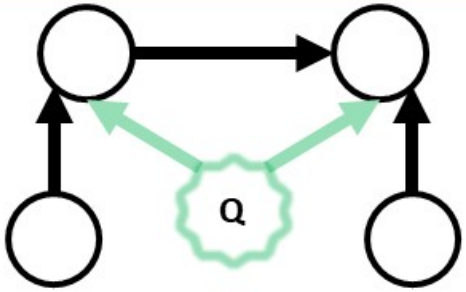
Recognizing quantum advantages

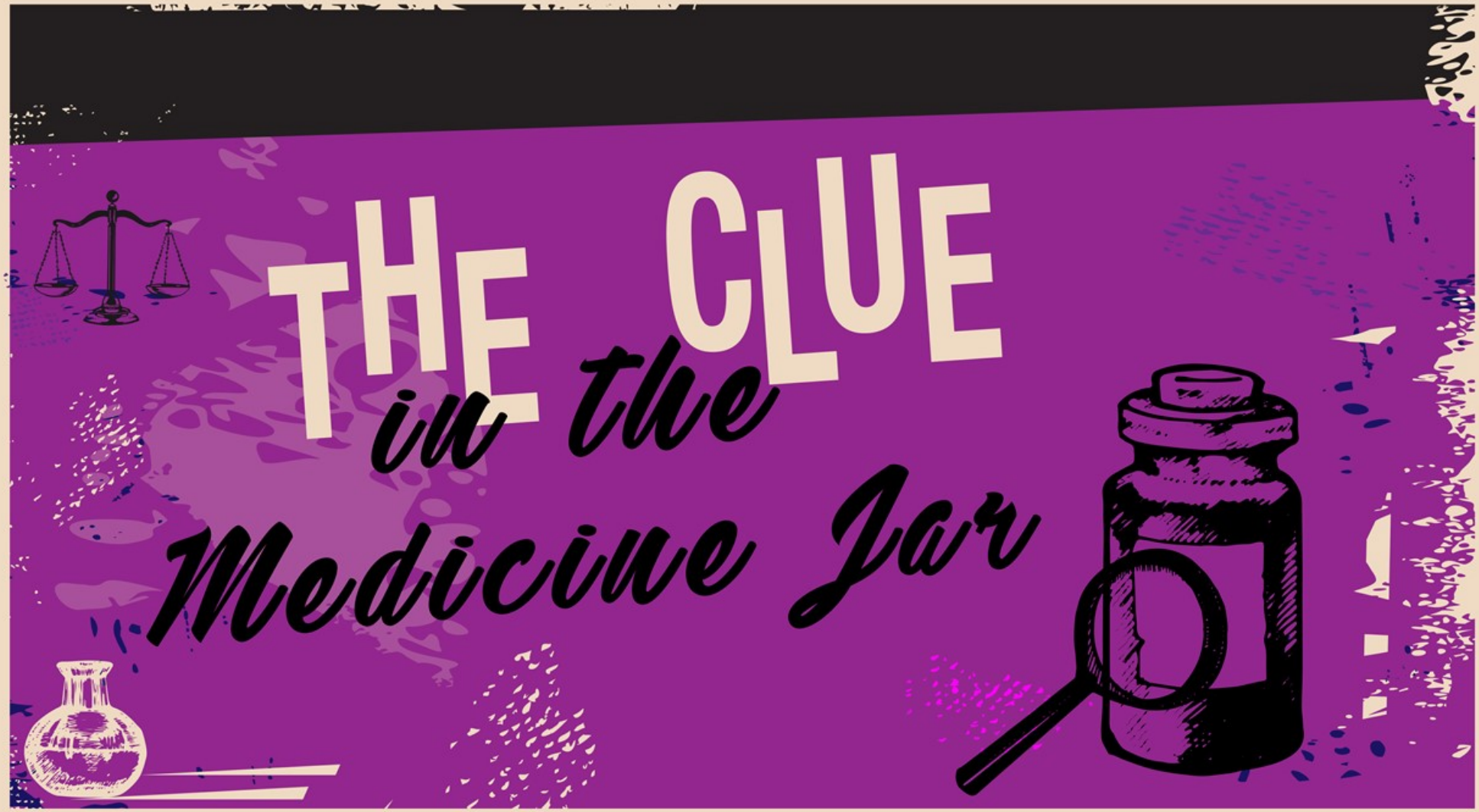




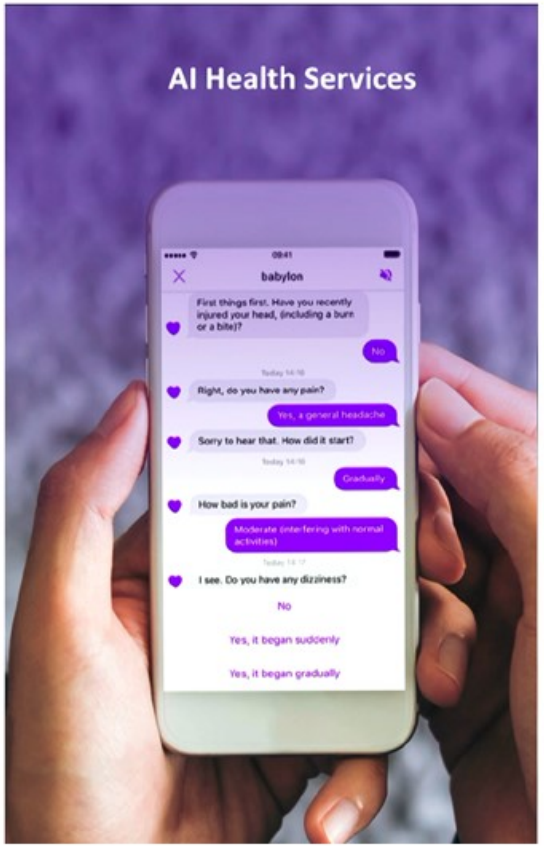
Quantum vs. Quantum

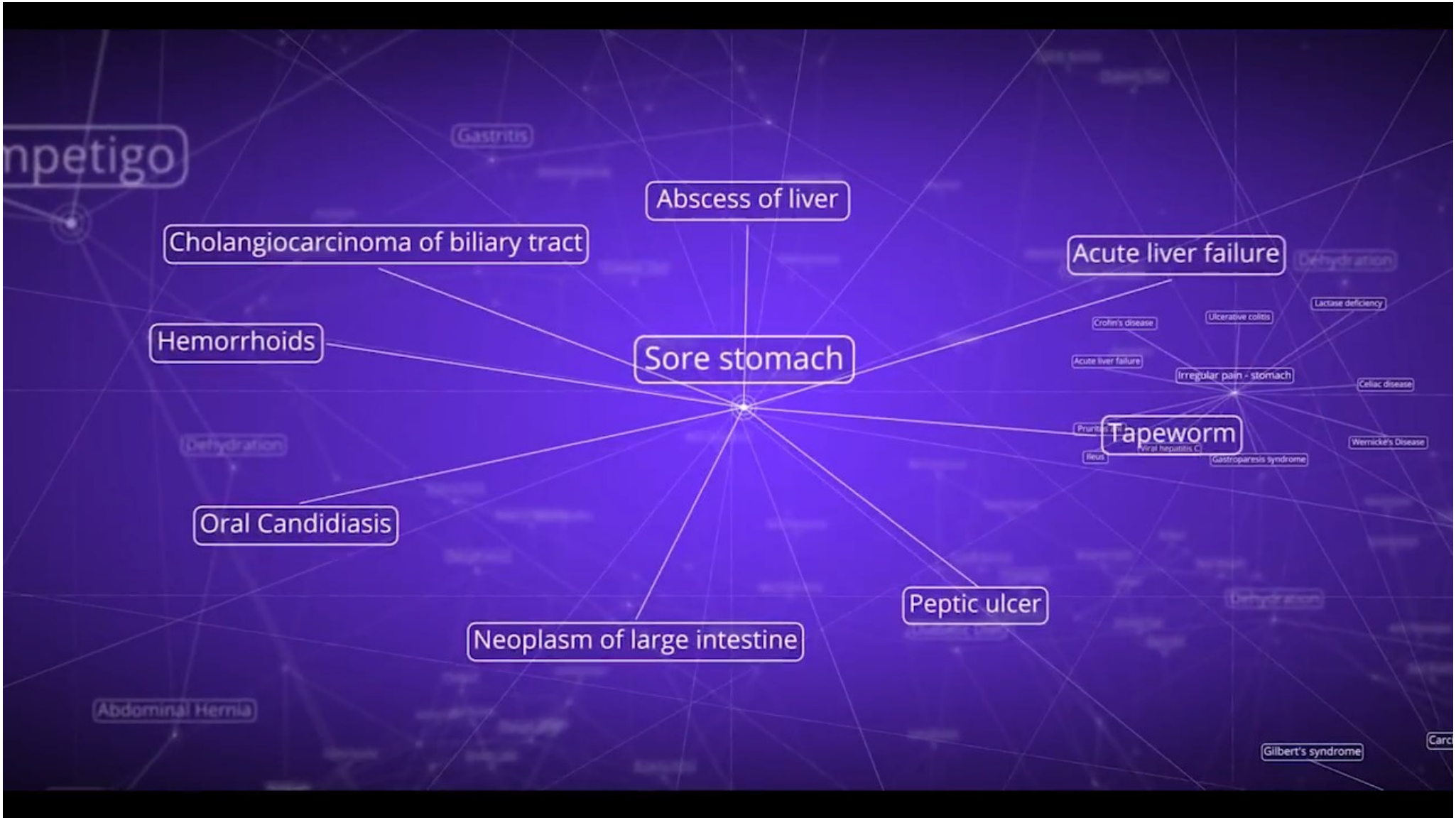
Diagnosing quantum processes

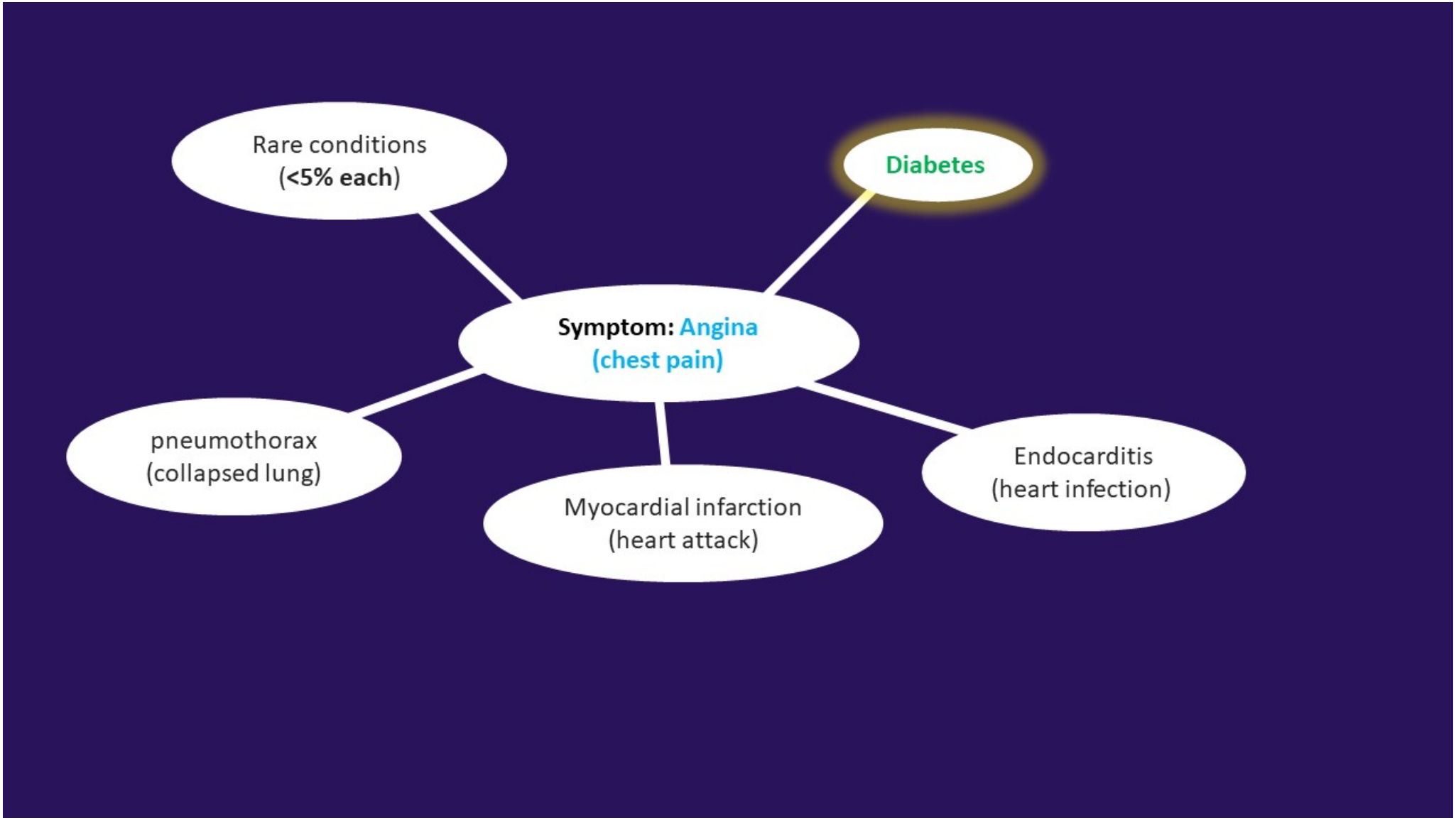


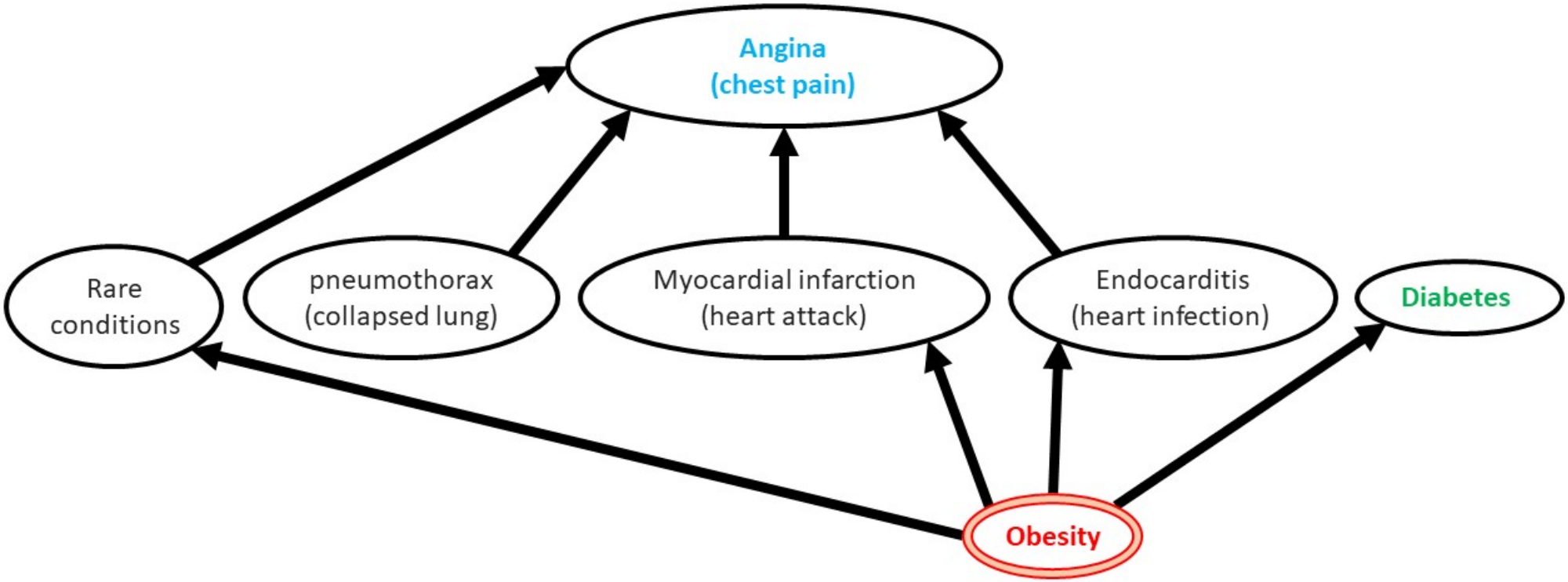

THE CLUE
in the
Medicine Jar

Ciarán M. Gilligan-Lee & Babylon Health




npetigo
Gastritis
Abscess of liver
Cholangiocarcinoma of biliary tract
Acute liver failure
Dehydration
Lactase deficiency
Ulcerative colitis
Crohn's disease
Hemorrhoids
Sore stomach
Acute liver failure
Irregular pain - stomach
Celiac disease
Tapeworm
Viral hepatitis C
Ileus
Gastroparesis syndrome
Wernicke's Disease
Dehydration
Oral Candidiasis
Peptic ulcer
Neoplasm of large intestine
Abdominal Hernia
Gilbert's syndrome


Rare conditions
(<5% each)
Diabetes
Symptom: Angina
(chest pain)
pneumothorax
(collapsed lung)
Myocardial infarction
(heart attack)
Endocarditis
(heart infection)


Angina
(chest pain)
Rare
conditions
pneumothorax
(collapsed lung)
Myocardial infarction
(heart attack)
Endocarditis
(heart infection)
Diabetes
Obesity

“Draw your assumptions before your conclusions.”

--- Miguel Hernán

Professor of Biostatistics and Epidemiology
Harvard University